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INDEX

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Road and Street Monthly Issue

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The four rotated special monthly issues and 4 quarterly issues of E. & C. (52 in all) entirely cover the civil engineering and contracting field at $3.00 a year. The special quarterly issues relate entirely to foreign engineering and construction practice. The *articles* in the first two issues of each month completely cover the municipal engineering and contracting field. The *articles* in the first and fourth issues of each month completely cover county engineering and highway engineering and contracting. The *articles* in the 3rd and 4th issues of each month completely cover steam and electric railway location, design and construction. See the "masthead" on the first page of the Weekly News Section for information about our weekly contract news.

Roads and Streets—1st Wednesday
- (a) Roads
- (b) Streets
- (c) Street Cleaning
- (d) Municipal Miscellanies
- (e) Management and Office System

Waterworks and Hydraulics—2nd Wednesday
- (a) Waterworks
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Railways and Excavation—3rd Wednesday
- (a) Excavation and Dredging
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Buildings and Structures—4th Wednesday
- (a) Buildings
- (b) Bridges
- (c) Harbor Structures
- (d) Miscellaneous Structures
- (e) Properties of Materials
- (f) Management and Office System

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E. & C. Index Furnished Only on Request

The Index for Vol. LII—July-December, 1919—issues of Engineering and Contracting is now being prepared. In common with many other publishers we have adopted the practice of sending the index to only such subscribers as request it. Therefore, if you want the index for the last 6 months you should notify us at once. Those who requested the index for the previous volumes have been listed and need not notify us again.

The Need of Engineering Propaganda to Secure Better Streets

Until about 30 years ago practically all road improvement was paid for by local road districts. The theory was that, since the main benefit from a road accrued to those that lived along or near to it, therefore they should pay the entire cost. Not until this theory began to be replaced by another one did we begin to secure good roads in America.

The new theory recognized not only that the public in general benefited greatly from road improvement, but that a great psychological obstacle made it exceedingly difficult to raise adequate funds for road building when the funds were raised by taxes on the property "directly benefited." The farmer could readily enough see the cost of a better road, but he was too short-sighted to see the annual profits from it. Moreover, he realized that the annual profits would be relatively small at first, and that it would be several years before he would begin to receive an adequate return on his investment in roads. Finally, he had no ready cash to spare for roads, and he was obsessed by a false economic idea that it was poor business for the public to borrow money for public improvements. All these factors held back road improvement in America for a century after it began to be badly needed.

It seems to us that the very same obstacles (plus one or two more) are now retarding the improvement of city and village streets. In relatively few cities is any part of the cost of a pavement paid for out of the general fund. The assessing of all, or nearly all, the cost of pavements against the abutting property has acted to restrict progress in street improvement. Fully half the mileage of all streets in America is unpaved. Of the half that is paved, probably half needs new pavement.

A short time ago the editor saw in New Orleans stone block pavements on many business streets, the blocks being slabs about 12x18 in. in size! Over this prehistoric pavement motor trucks were bouncing like rowboats in a tempestuous sea. Many other streets were even worse — nothing but mud. While we cite New Orleans as an example, we need not leave Chicago to find

28 Pages=40 pages

The 28 pages of articles in Engineering and Contracting contain as many words as 40 pages of the size and typography commonly used by other engineering periodicals. Ours is the same size of type and type-page as that of The Literary Digest—easily read, yet giving a large volume of reading matter per page. Our 28 pages of articles would fill 112 pages of the standard 6x9 in. text-book. It would take 10 such books of 580 pages each to hold all the articles printed each year in Engineering and Contracting, to say nothing of our weekly construction news.

miles upon miles of streets that are as bad. Indeed, the American city that can boast of having more than half its street mileage well paved is justified in boasting.

Now it is not lack of wealth that prevents the universal paving of our streets; nor is it because it would not pay the public to pave them all. What is needed is better laws and aggressive publicity. Engineering societies can secure the one and assist in supplying the other.

Let Engineering Societies and Periodicals Support an Engineer for the Presidency

Scientific methods and scientific men will never receive adequate recognition by the government until a man of scientific training becomes president. For the first time in American history two such men are being widely suggested for that office—General Leonard Wood and Herbert Hoover.

Gen. Wood was a physician before he became a military man. Then he educated himself in military engineering. He is a member of the American Association of Engineers.

Mr. Hoover is a graduate mining engineer and is a member of the American Institute of Mining and Metallurgical Engineers. By the editors of daily papers he is commonly spoken of as a business man, which he is. He is a great executive, and his greatness is largely due to his scientific training as an engineer.

In the Saturday Evening Post of Jan. 3, Samuel G. Blythe names three business men whom the nation should consider as suitable candidates for the presidency. It is significant that he names Herbert Hoover first. Of him he says:

> The fact that a man has been successful in building up a great manufacturing concern or a great merchandising concern or a great selling or financial organization does not of itself fit him for the Presidency. He must have more than that. He must have not only his knowledge and experience of private business but some knowledge and experience of public business in order that he may conserve the needs of each—co-ordinate them and make them both effective. He must know the machinery and operations of public business as well as those of private business.
>
> To begin with, there is Herbert Hoover. He is admirably placed so far as political affiliation goes, because some of his friends say he is a Democrat and some say he is a Republican; and, from all I can learn, he has never said what he is so far as his politics is concerned. Thus he might be impressed on either party, or both, by a demand of the people should the people, on scrutiny, be satisfied of his qualifications. Hoover is a business man. He understands not only American business but international business, which will be of vast importance to this country in the next few years. He has had a large administrative experience. He knows the machinery of government as well as the machinery of popular affairs. His position, so far as announced, on the important topics of the day is sound in a business sense and sound in a governmental sense. He is known in every community in the United States, and equally well known in foreign countries. He has done a big job in a big way. Conversely, he may entertain convictions that may be more radical than this country can assimilate. I do not know that he does. That is subject to declaration on his part.

It may be too early in the evolution of the association of scientific societies to hope for concerted effort to secure the nomination of scientific men for political offices. But it is certain that the public has at last grown weary of professional talkers and would welcome leaders trained to solve economic problems by the use of quantitative data instead of the use of voluble debate. The era of the country town debating society is about to pass away forever. The shallow reasoning and the deep ignorance of the stump speaker have had their day—yes, their 143.5 times 365 days, or ever since the United States came into being. The era of experimental science, as applied to political problems, is in its dawn. Is this first glow of it too dim yet to justify the hope that a scientific executive can be nominated for the presidency?

One great national weekly and many leading daily papers are advocating the experiment of nominating for this great office some one who is not a lawyer or a professional politician. The Saturday Evening Post, in several editorials, has advised the nomination of a business man. Why should not all engineering societies and engineering periodicals join in this propaganda, centering upon an executive who is both a business man and an engineer?

Some Public Ownership Fallacies

At the last annual convention of the League of California Municipalities a paper entitled, "The Success of Public Ownership of Public Utilities" was read by C. W. Koiner, manager of the Pasadena electric light plant. His paper contains many misstatements, half-truths and exaggerations. We are less concerned with these than with his erroneous reasoning. We quote:

> It is beyond dispute that the municipality can serve itself with electrical energy or with gas or with transportation cheaper than it can be served by privately owned utilities. One reason is because the city can borrow money at half the rate a private company must necessarily pay to finance its enterprise, which in itself means a big saving; then, in writing off the depreciation charge from year to year and retiring the indebtedness there is a certain amount put into the plants that keep them well up in value. At the end of a certain period, the bonded indebtedness is reduced to a minimum, thereby reducing the annual tax on the investment for the value of the property remaining, as compared with the annual tax of dividends on the outstanding bonds and stocks of a private concern. If you and I should own a private utility of this kind, we would keep our stock up and dividends going along on the original value. It is not so with the municipality owned utility, for they are reduced from year to year until finally you will find in existence some plants almost free from debt. In fact, when the original capital has been retired, they put in money from the earnings, at lower rates than they would have paid under private ownership.

Mr. Koiner begins with two assertions that he can not prove, and he ends with an economic fallacy. The fallacy consists in the argument that a municipal plant saves money for its patrons by retiring the bonds and thereafter charging a lower rate for service. This fallacy reappears again and again in the arguments of municipal ownership advocates. It is easily disclosed by asking where the money comes from to retire the bonds. It must come either from taxes or from rates that are made sufficiently high not only to pay interest on the investment but to amortize the investment. In either case the public pays more than interest and operating expenses. If the tax payers or patrons did not thus pay the city more than is necessary they could invest the money thus taken from them. So there is no economic gain whatever as a result of amortizing the investment, and there may be a loss. There is a loss whenever the interest rate on the municipal bonds is less than the average interest and dividend rates that individuals secure on their private capital.

Mr. Koiner passes from one fallacy to another. He says:

> To deny that a municipality or a state cannot own and operate its public utilities is to acknowledge that we, as a people—as a democracy are failures. It is almost equivalent to saying that, as a people, we cannot trust ourselves to operate these things, and that I always resent. There is an implied thought there, an inference that we are so dishonest in public office and public life that we cannot conduct these things honestly to the satisfaction of the community served, and that I say is a libel on the honesty and intelligence of the American people. I don't believe any such statement, and I feel sure that you do not, either.

The fallacy here consists in assuming that there is only one cause of the economic failure of municipal ownership, namely dishonest political administration. As a matter of fact there are many causes, chief of which are the following: (1) Inefficient management due (a) to the inability of the public to judge managerial efficiency, and (b) lack of adequate pecuniary incentive for the manager to do his best. (2) Inefficient workmen, due partly to poor management but largely to the tendency of workmen to loaf when the employer (in this case the public) is not watching them.

The public rarely pays managerial brains an adequate salary, and was never known to pay a municipal plant manager a bonus for excellence of performance. The public may sometimes know the distinction between very good and very poor performance, but beyond exceedingly crude judgment of managerial efficiency the public is unable to weigh merit.

The public not only has no ability to judge the economic efficiency of its own plants, but rarely hires independent experts to investigate the economic efficiency. Instead it swallows what its managers tell it, regardless of the fact that the manager naturally will paint his own achievements in glowing colors.

Mr. Koiner points to the low rate charged for domestic lighting, but he says nothing about the fact that a private company has frequently offered to light the streets of Pasadena at much less than the city plant is charging for that service. It is a trick of municipal plant managers to lower the rates for domestic lighting and raise the rates for street lighting. It pleases many voters to find small monthly bills for lighting; not one in a hundred ever thinks to ask whether his taxes have not gone up because the street lighting costs two or more times what it should cost.

"The success of public ownership" can never be proved or disproved by partisan claims. Only an impartial analysis by competent engineers can be relied upon to settle the question properly. To any one but "the public" this is self-evident, but we do not recall a single instance in which "the public" has ever pursued this self-evident method of solving the municipal ownership problem. Instead "the public" has its opinion formed for it by its own permanent employes who naturally seek to hold their jobs, or by politicians who seek new issues and jobs for themselves and their adherents, or by newspaper editors who know nothing whatever of engineering and managerial economics.

It would be a matter for mirth, if it were not so pitiable, to see how "the public" does its "reasoning" on municipal ownership. This pitiable condition will continue until engineers convince the public that on involved economic questions it should call upon engineers to reason for it.

Who Originated the Term "Science of Management"?

The October "Bulletin of the Taylor Society" contains an article prepared by the managing director of that society for the forthcoming new edition of the Encyclopedia Americana from which we quote the following:

"It was at these hearings (before the Interstate Commerce Commission in 1911) and in the title of a book which Taylor published at this time (Principles of Scientific Management, 1911) that the term, scientific management was first used."

We are surprised that H. S. Person, the author of this statement, should make a claim of this kind.

In 1908 there was published by the American School of Correspondence, Chicago, a book entitled "Cost Analysis Engineering," by R. T. Dana, containing an introductory section by Halbert P. Gillette. In that section Mr. Gillette said:

"The Science of Management.—The managing of industrial enterprises is still more or less of an art; but the art is fast passing through the period of evolution that produces a science. There are, unquestionably, certain underlying principles of management which can be summarized into rules or laws. These rules or laws constitute the science of management, and it is our purpose to present certain of the more important laws of management."

Then follow some half a dozen of the laws of management, forming the first published code of the laws of the science of management. A year later, in 1909, a much more complete code of laws of management was published in "Cost Keeping and Management Engineering," by Halbert P. Gillette and Richard T. Dana. This book was the first book on the science of management to be published, and it was dedicated to Frederick W. Taylor as a tribute to his pioneer work in publishing two important papers in the Transactions of the American Society of Mechanical Engineers. The first paper was entitled "A Piece Rate System" (1895) and the second was "Shop Management" (1903). In neither of these papers did Mr. Taylor show that he had a conception of establishing a science of management, nor did he use that term. In fact he called his special system of shop management an "invention," or new combination of four old elements.

Scientific management there was long before Taylor lived, for any method that involved systematic study of methods of management and their quantitative results was scientific. Prior to every science there are scientific principles. Taylor failed to see that the time had arrived when all the known principles of scientific management should be formulated and presented as a science of management. This was precisely what Gillette and Dana were the first to do.

In the preface to their book on Cost-Keeping and Management Engineering, written in 1908 and published in 1909, we read:

> That there are any scientific laws of management will be denied by many men of the old school, but such denial cannot be logically maintained. * * * In a subject so complex it is impossible for any one man to discover all the laws of management. Each student of the subject will be able to add his quota, until, in the course of the next few years, the science of engineering management will become as complete as any of the other younger sciences. * * * In the application of the laws of this new science of management, the first requisite is a record of daily performance of each working unit, whether the unit be an individual workman or a gang of workmen. This recording of the performance of workmen is called cost keeping. * * * Cost keeping has been evolved by managing engineers, and is essentially a system for showing the efficiency of workmen and of machines. * * * In no other book hitherto published has an attempt been made to present not only methods of cost keeping but the principles of the science of management. * * * As high an order of engineering is required in mastering and applying the laws of engineering management as is required in calculating a stress or in selecting the means to resist it.

Then followed ten "laws of management" and 17 subsidiary principles or rules. Although the authors preferred to use the term "Management Engineering" to cover the science of management, they used both terms repeatedly in this book, two years before Taylor wrote his "Principles of Scientific Management," and a year before Emerson wrote his "Twelve Principles of Efficiency."

Aside from the Golden Rule, which he phrased in the language of poker players—"the square deal"—Emerson added, if we remember, nothing to the 10 laws of management and the 17 principles that had previously been given by Gillette and Dana. Taylor, in his "Principles of Scientific Management," did not even give all the 10 laws given by Gillette and Dana, but merely rewrote his original paper on "Shop Management."

Taylor is entitled to great credit for his pioneer work, but he certainly did not conceive the possibility of producing a "science of management" nor did he coin that term.

Breaking the Record for Highway Advertising

This issue of Engineering and Contracting breaks all records for highway advertising. Never before has a periodical devoted to highways carried 100 pages of advertising, yet the year has just begun. We regard this as conclusive evidence that the manufacturers of road and street machinery and materials anticipate an exceptionally big year. Certainly the enormous appropriations for state and county road work justify such an anticipation. Yet America is only just beginning to build roads in earnest, and is far behind European countries in per capita mileage of hard surfaced highways.

Our February Road and Street issue will contain more advertising and more articles than the present issue, for it will be the "convention issue." The American Highway Association holds its annual convention in Louisville, Ky., Feb. 9 to 13. Let every highway specialists attend if possible.

Types of Road Construction on Lincoln Highway.—The Lincoln Highway, extending from New York City to San Francisco, has a total mileage of 3,323, consisting of the following types of construction:

	Miles.
Concrete	294.84
Brick	212.58
Bituminous macadam	425.61
Macadam	286.65
Asphalt	78.00
Creosote block	5.90
Granite block	7.10
Graded gravel	770.75
Natural gravel	200.00
Shale	17.00
Graded dirt	817.57
Natural dirt	93.70
Sand	13.30

U. S. Laboratory Examines Samples for Road Builders.—The special laboratory devoted to the microscopic examination and classification of road-building rocks, maintained by the Bureau of Public Roads, U. S. Department of Agriculture, has examined 686 samples of material during the past year, according to the chief of the bureau. This represents a considerable increase over the preceding year. Of the samples examined, 249 were rock, 41 slag, 151 gravel, 189 sand, 45 clay, and 11 miscellaneous.

Unionism and the Engineer

To the Editor: I have just read with interest the pronouncement of the officers of the American Association of Engineers which closes with the statement, "The American Association of Engineers . . . recognizing the many fundamental differences between the principles and objectives of the trade union and of an organization of professional men expresses the opinion that an engineer cannot subscribe to the tenants of both." This is a frank statement made by gentlemen whose opinions are worthy of serious consideration. As a member of a union I feel, however, that there is another side to this question, a side which also deserves careful consideration. This side I will endeavor to present as briefly as possible.

Society, speaking generally, organizes along two pretty well recognized lines which may be defined as aristocratic and democratic. Aristocratic organizations, whether national organizations or minor organizations, depend for their leadership on those in the organization who have attained to positions of more or less prominence. Democratic organizations choose their leaders from the rank and file of the organization. The king must be a man of blood and long ancestry, but a humble rail splitter can become the most conspicuous leader of the largest republic on the globe.

The same difference holds, today, in the various organizations open to civil engineers. The older societies are intensely aristocratic in their organization. The officers who control the policies of these organizations are chosen from among the prominent men of the profession. This is perfectly proper but it results in a type of organization not well suited to appreciate or to handle the needs of the rank and file of the profession.

The same thing may be said of the American Association. Its officers and directors are men of national prominence—aristocrats of the engineering profession—and, while it is not intended that this shall imply the slightest criticism either of them or of their purposes, organizations of this nature, whether large or small, lack in that basic fundamental so brilliantly expressed by Mr. Lincoln in his statement "of the people, by the people and for the people."

And, just here, lies the difference between these organizations and a union. A union is a democracy. It does not depend on the great for its leadership—it finds its leadership among the men who form the mass of its membership.

There is no fundamental difference between the principles of a union, its purposes or its ambitions and those of any other organization except that, as in any democracy, the real ambitions and the real purposes of the rank and file find ready expression; whereas, in an aristocratic organization, this expression is apt to be supressed because of the conservatism of the leadership. To assert superior ideals for the association and a higher code of professional ethics is to assert that its leaders possess higher ideals than those held by the rank and file of the profession who would join and make effective a union. This is, doubtless, the opinion of the gentlemen who issued the association's manifesto but other men are at liberty to hold contrary views. The claim that the association "does not use union methods" is, therefore, only a reflection on the association—none whatever on the unions. True, organizations as skillfully led and managed with the dignity which is a feature of the American Society of Civil Engineers are an ornament to society. It is also true that organizations managed with the democratic directness of the brick layers union annoy sensitive individuals a great deal. But the fact that a fair brick layer draws a bigger pay check every month than even a pretty good engineer should cause engineers to seriously consider whether it is not true that this dignity and the high professional standards so much discussed by the leaders of our engineering organizations are not costing the rank and file of the profession entirely too much.

After all, the truth of the matter is that engineers, like all other rational men, work for the purpose of earning a living. In this day and age they must combine, as other men do, to act collectively on wages and working conditions or they will fall into even a more miserable condition than that which they now occupy. They can, of course, continue to trust the leadership of their organizations to the influential men in the profession and these men will, beyond a question, continue to lead in the way which seems to them to be best, but the rank and file of the profession should realize that there is a vast gulf fixed between the man who lives by dint of his own efforts and the man who lives better by reason of the success with which he can manage the activities of others. Society needs both classes but it is not reasonable to suppose that the man who employes men will view the problems of these men as they do themselves.

It has, for many, many years, been the cry of the aristocrat, no matter in what sort of an organization he was found, that democracy is dangerous. So, today, the aristocratically led association decries unions and union methods and states that a man cannot be an engineer and belong to a union. Democracy is dangerous!! It is—to the position of the aristocrat.

But, no matter what ideas one may hold as to professional ethics, high ideals, dignity, etc., the fact remains that even the subordinate engineer must make a living. Under his present leadership, salaries have gotten so out of line with living costs that engineers, as a class, are in desperate straits. Therefore, it would seem to be time for engineers to take matters in their own hands and, at the risk of the loss of some of the splendid dignity which marks the masterful diplomacy of the present engineering organizations, lay down and enforce a few rules as to remuneration for professional services. This does not imply any loss of principle or any loss of professional standards. But it does imply the need for greater democracy in organization and much more directness in methods.

Finally let me ask engineers to seriously consider the question as to what salaries the railroad firemen, engineers and conductors would be getting today if, for a board of directors, they had the presidents of the C. & N. W., C. B. & Q., Pennsylvania, New York Central and Union Pacific railroads? Or what wages would a coal digger be getting if he had entrusted his affairs to a committee of three of the big mine owners? There is food for much thought in these questions.

The profession today needs a number of things very badly. But, most of all, it needs added remuneration for the rank and file of the profession. It is easy enough, as the association does, to pay lip service to the doctrine that "rewards should be according to ability, initiative and constructive effort." It would be vastly more to the point, however, to know that the gentlemen who, claiming superior professional ethics for the body of which they are the directing heads, are, themselves, paying the men who they employ enough more than they did five years ago so that these men can maintain the social position they then possessed!!

J. L. HARRISON.

Surveys of State Roads in Missouri.—Nearly one-third of the state road system of Missouri, authorized under the new road law had been surveyed on Dec. 1. The law designated 6,000 miles of state road and directed the State Highway Engineer to make surveys and maps of this mileage. Surveys have been made in whole or in part in 86 counties. In the remaining 28 counties no start has been made, but work in them will begin as soon as the weather permits in the spring.

Civil Service Examinations for Engineering Positions.—The State Civil Service Commission, Albany, N. Y., will hold examinations this month for the following positions in office of New York State Engineer and Highway Department: junior assistant engineer, grade 2, $1,980 to $2,280 per year; junior assistant engineer, grade 1, $1,620 to $1,860; engineering assistant, $1,080 to $1,560. Applications must be filed with the State Civil Service Commission by Jan. 20.

Early Start to Be Made on Washington Road Work. The State Highway Commissioner of Washington plans to start work on 60 miles of federal aid road construction as early in the spring as weather conditions will permit. This means a three months earlier start on the state paving program mapped out for next year, in which federal aid is involved to the extent of nearly $1,500,000 in funds to be added to the improvement funds.

Wisconsin Road School.—The 9th annual road school will be held under the auspices of the State Highway Commission, at Madison, Wis., Jan. 26 to 31, inclusive. Upward of 700 registered for last year's school and it is expected that at least 1,000 will be in attendance this year.

Can Originality Be Taught?

By HALBERT P. GILLETTE, Editor.

The opinion always has been prevalent that originality is not teachable. Is this opinion founded on so many observed failures to develop originality that it is entitled to be called an induction from experience? Or is it one of the numerous false generalizations that have been arrived at by a process of deduction from questionable premises?

After a careful study of the facts assigned in support of the proposition that originality can not be taught, I have concluded that they are all deductions resting upon debatable premises. On the other hand, there are many experiences that support the theory that originality is teachable. But before discussing some of them, let us consider, for a moment, what we mean by the word "teach."

Teaching, in its broadest sense, means not only the imparting of facts but the training of the mind or body or both by a teacher. No one contends that a mind entirely void of inherited ability in a given field can be developed by training. All that training can do is to develop or strengthen the powers that are inherited. Is originality inherited in some measure by most men?

Those who have studied many children assure us that they usually exhibit a "lively imagination." But what is that if not originality The power to combine parts of existing mental records so as to form novel wholes, whether in sleep-dreams or in "day dreams," is nothing else than the power to imagine, to create, to invent. It is true that we use the words "create" and "invent" to designate subclasses of the term "imagine"; but when we come to study the real meaning of these three terms we see that they all involve the power to originate. Now this inherited power to originate may be feeble or it may be strong, but in any case it is susceptible of becoming stronger under proper training, or of becoming atrophied or weaker if not properly exercised.

Not only is this conclusion rendered probable by analogy with other mental powers, but it is made evident wherever a group of men have come under the influence of a strongly inventive mind. Many of the graduates of Edison's laboratory have expressed indebtedness for his training. So, too, have the students of every educator noted for originality. Read, for example, the tributes to that great Swiss-American genius, Louis Agassiz, who taught for many years at Harvard. Prof. Shaler, in particular, is very emphatic in acknowledging that Agassiz taught him how to observe and discover.

Innumerable writers have commented upon the strange fact that creative intellects seem to occur in groups. There were the Aristotolean group, the Elizabethan group, and the Cambridge group, to mention only three great literary groups one in Greece, one in England and one in America. But note particularly that in every case these groups were composed of men who were in frequent, personal communication with one another. Is this not significant? Does it not indicate that some one man of exceptional genius developed unusual originality in certain other men about him? Either it indicates this, or else these men developed originality in one another. In either case, such phenomena show that originality is increased by training.

Let us turn to a much broader and perhaps more convincing class of facts—the number of inventions and discoveries produced by each of the different countries.

The following table shows the total number of patents issued by each of 13 nations up to the end of 1915, and their respective total populations in round numbers:

	Population.	Patents.
America (U. S.)	103,000,000	1,057,802
Austro-Hungary	50,000,000	156,975
Belgium	7,600,000	242,267
Canada	7,700,000	166,199
France	39,600,000	404,514
Germany	66,700,000	296,514
Great Britain	46,100,000	450,440
Italy	35,600,000	129,428
Norway	2,500,000	27,520
Russia	175,000,000	30,844
Spain	20,400,000	54,390
Sweden	5,700,000	41,588
Switzerland	3,700,000	72,275
	563,600,000	3,128,756

All the remaining countries in the world had issued fewer than 300,000 patents up to 1915.

It will be seen that these 13 nations averaged one patent issued for every 180 people then living. Belgium shows the highest average, with a patent for every 30 people; Canada and Switzerland stand next with a patent for about every 50 people. Russia (the present would-be leader of the world in originality of government) stands at the foot of the list with one patent for every 60,000 people!

France, Great Britain, Norway and America are neck and neck with about one patent per 100 population, but it should be remembered that these foreign countries have been issuing patents for a longer time than America.

That certain of the smaller countries stand unusually high is due to the disproportionately large number of patents issued by them to foreigners resident in the larger countries.

It will be noted that where general education is very good, patents are very numerous, and that where it is very poor (as in Russia, Austro-Hungary and Italy) patents are very scarce. Evidently, there is some direct relation between education and inventiveness; but it may still be contended that no special training to develop originality is required, even though it is admitted that originality increases with increased knowledge.

If we consider the different fields in which originality manifests itself most strongly, we are impressed at once with the fact that there are wide differences between countries whose general education is substantially the same.

Turn first to France. We see there a predominent originality in artistic matters even to artistic dress. Yet in the early days of science France led the world.

Turn next to Germany. We see there a predominent originality in chemical and physical research, in applied chemistry, and in the art of music. Yet it was not many generations ago that German music was mostly borrowed from Italy, and pure science from England and France.

Turn next to England. We see there a predominent originality in textile machinery, in physical research, and in the art of poetry. Yet England was also once the leader in pure chemistry, in nearly all lines of mechanical invention and in literature of every sort.

Turn next to America. Here we see a predominent originality in mechanical inventions, in scientific agriculture, in advertising, and in the arts of humor, short story telling, and film drama. Yet America is "the melting pot" of Europe. Why then is it not equally original in all the sciences, pure and applied, and in all the arts?

The answer is obvious. Originality begets originality. One original mind inspires other minds to become original, and not only inspires but trains them to become more inventive. If this were not so, all educated nations would be about equal in originality in every field.

Genius, it is true, attracts genius, but it does more. Genius inspires, and it teaches. The great pity is that our educational system does not give more practical recognition to this fact. The greatest teachers—the great originators—are frequently not on the faculty of any school or college. And unfortunately they are usually so absorbed in building a reputation or a fortune that they spend little time in developing greater originality in other men.

A teacher of engineering recently wrote this:

> It certainly sounds like a noble thing for a professor to aspire to teach his pupils to think and to do research work and to accomplish something beyond the mere acquisition of information. Articles written with such ideas in mind and proposing to teach students to invent and originate, read very beautifully. I feel, however, that such articles are only visionary and that the writers have their heads in the clouds.
>
> An almost negligible percentage of pupils have power to invent and do original research work. This power cannot be given by any amount of instruction. If courses are therefore planned with the idea of developing such powers, they will only suit an exceedingly small percentage of the pupils. It is very often the case that the majority of the pupils in the class are in a haze as to what the instructor with such ideals is talking about.
>
> If any engineering instructor will take a census as to what his pupils are doing five or ten years after graduation, he will find very, very few doing original research work, and a very large majority using detailed information of various kinds which they have to grope for in engineering handbooks and the like, because they were not given concrete details during their college course. The very few pupils who are fitted to do research work and think independently have no need of any special training in this direction. They can profit greatly by the same sort of course as is given their less original classmates. They themselves have the necessary power to add to such a course, whatever is necessary.

I can not agree with such statements, further than to admit that most practicing engineers do very little that is original. But this latter condition proves nothing unless it be that their education has atrophied their originality. By a parity of argument one might claim that since Russia has produced only one invention per 60,000 of population, therefore there are no inventive brains in Russia. If general and technical education has resulted in making the French, Germans, English and Americans 600 times as inventive as the Russians, there is assurance that originality and education do go hand in hand. If one of these four leading nations is noticeably inventive in certain lines, another in other lines, and so on, there is assurance that different teachers and different methods of teaching (whether in school, or in factory, or in studio) produce noticeably different development of originality in their pupils or co-laborers.

If systematic training for developing originality is not yet to be given to all, at least let it be given to as many as seek it. The time has come to cast out that "evil spirit" of education which continually cries: Only the few, by the grace of God, can ever be original.

How to Get Motor Trucks Out of Ditches

Any highway transport operator will sooner or later find himself facing the problem of getting a motor truck out of a ditch. Sooner or later an accident will happen, which will throw a big loaded van off the road, with heavy damage, if not actual catastrophe. At the least there will be the problem of getting the motor truck out and on the road again, with the least possible loss of time. Several useful methods of accomplishing this are described in a recent issue of The Power Wagon.

To be prepared in the first place, every motor truck should have the ordinary emergency equipment of cable, wheel chains, and the simple expedient of a bundle of burlap bags, old and worn. The bags are used for packing the loads to prevent damage to shipments, and when needed are of untold value in giving traction to a whirling drive wheel.

The miring of a motor truck in soft roads is always a mean problem, and one which would to the novice appear to be easily solved. Too many drivers have not yet learned the first lesson of combating such a situation, which is to hold the front wheels steady in the rut in rutted, sticky road. The moment the driver tries to climb out of the rut with his front wheels, the momentum is lost, and the front wheels act as a plow, actually blocking the movement of the motor truck. In a rut in a bad road, the driver should take care to keep moving above all things.

The power of a motor truck is sufficient to pull it out of any such mud, however, if the power can be applied. That is why at times a machine traveling light will get stuck, where a loaded one will keep moving. The weight on driving wheels is such that they cannot spin, and the machine is forced to move.

An interesting example of this was an experiment made by one of Uncle Sam's soldier chauffeurs in an American motor truck school. A convoy of motor trucks was out on the road on a night drive, preparing for service in France. One of the leading machines was mired, when the driver tried to climb out of a rut, and the front wheels merely piled up the mud in front, like a snow scraper. Momentum was lost and the motor truck stuck.

One of the drive wheels was on hard ground, the other in the mire. The motor truck was empty, and all efforts to move it on its own power resulted merely in a spinning of the wheel in the mire. The drive wheel on firm ground idled. After an hour of experimenting, the driver put a dozen husky soldiers in the machine, so their weight was over the spinning wheel. Then giving the motor truck the gas, the mired wheel had traction, being forced down to hard soil under the slime, and the power was applied both to the wheel on hard ground and to that in the mud, and the motor truck rolled out like a factory test run on concrete.

The machine in the ditch is as much a problem of head as of truck. Another army experiment is a lesson on this point. A driver found his motor truck slipping over a high embankment. A dozen men were in danger of being pinned by a capsizing motor truck. Instead of trying to hold the motor truck out of the ditch when he found it in danger, he threw the vehicle head on into 2 ft. of water, but averted the overturning of the machine.

The power of any average motor truck was shown by the work done in getting this vehicle on the road once more. It was covered with an army tarpaulin cover, was over a bank so high that the top of the cover was level with the road, and yet another motor truck, also 1½-ton type, pulled the machine to the road once more and sent it on its way in 20 minutes. This was the method: The heavy motor truck attached its towing cable to the rear end of the ditched machine. A ¾-ton ambulance type machine, known to the French as camionette, threw a rope around the side of the motor truck to prevent it from capsizing on the side of the road. When the word was given the ditched machine went into reverse, the towing motor truck and the machines walked out on the third attempt to the solid road. The power of two motor trucks was therefore used to climb the embankment, while the third was merely a steadier.

In a ditched truck it will often be found unnecessary to unload any of the cargo which is securely lashed. A cable or heavy rope thrown around the body, attached to a solid post on the opposite side of the road will serve to bring the motor truck right side up, without unloading. The use of a block and tackle on the cable thrown around the body, will make it possible to pull the machine to its feet again, and then the problem is only that of traction.

Pennsylvania in 1919 Let Road Contracts Totaling $27,000,000

Construction contracts awarded by the State Highway Department of Pennsylvania from the beginning of 1919 up to Dec. 1 covered 648.78 miles of roads, the contract price for this work being $27,020,121. This includes contracts for the state on state highways, county contracts and state aid contracts. The total advertisements by the department during 1919 were for 913.87 miles of new work. This figure does not include re-advertisements made necessary through rejection of bids.

The types of construction provided for in the state highway, state aid and county contracts awarded during 1919, up to Dec. 1, with the price contracted for each type, were as follows:

Type.	Mileage.	Contract price.
Reinforced concrete	486.21	$21,558,112
Bituminous concrete	103.95	4,282,121
Brick	6.75	383,001
Sheet asphalt	50.61	758,346
Plain concrete	1.26	38,541
Total	648.78	$27,020,121

The contracts let by various Pennsylvania counties and included in the total given above are for 24.10 miles—reinforced concrete, 19.74; and bituminous surfacing, 4.36 miles—at a contract price of $956,054. The contracts awarded for the primary and secondary highway systems and state aid on highway routes were for a total of 588.13 miles, at a cost of $24,665,450. This mileage included: reinforced concrete, 438.53; bituminous concrete, 103.95; brick, 6.75; sheet asphalt, 37.64; plain concrete, 1.26.

On the primary system alone the following contracts were awarded:

Type.	Mileage.	Contract price.
Reinforced concrete	381.49	$16,943,031
Bituminous concrete	94.49	3,903,594
Brick	5.81	328,158
Sheet asphalt	29.56	300,889
Plain concrete	1.26	38,540
Total	512.61	$21,514,212

Contracts awarded for state aid not on highway routes were for 27.94 miles of reinforced concrete and 8.61 miles of sheet asphalt. A total of 36.55 miles, the contract price of which is $1,398,616.

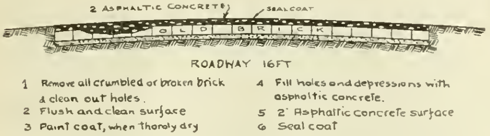
Considerable work also was done by the state highway department in boroughs. For example, the state paid the entire cost of the construction of 18.49 miles of concrete in boroughs on the primary system, at a contract price of $862,912. The price for 2.98 miles of new work in boroughs on state aid or state highway routes was $138,457. Borough construction on the state aid plan, the boroughs not being on highway routes, were for 2.61 miles of new roadway, at a cost of $94,404.

Method of Resurfacing Worn Brick Pavement With Asphalt

By CHARLES E. MURPHY,
The Texas Co., New York.

Perhaps no other section of the country has attained more success in resurfacing worn brick pavements with asphalt than has been accomplished throughout the states of the middle west. Topeka and Wichita in Kansas; Kansas City, St. Joseph and St. Louis, Mo.; Lincoln and Beatrice in Nebraska, and Fort Smith in Arkansas, are among the cities which have successfully treated their worn brick pavements with either sheet asphalt or asphaltic concrete wearing surface.

Many of the older brick streets are paved with brick inferior in quality to the brick being used today. Under traffic some of these old brick pavements have worn badly and have become rough. An economic survey of conditions has revealed the fact that much of the original investment may be saved to the property owners by utilizing the worn brick pavements as a base for an asphaltic wearing surface.


2 ASPHALTIC CONCRETE
SEALCOAT
OLD BRICK
ROADWAY 16FT
1 Remove all crumbled or broken brick & clean out holes.
2 Flush and clean surface
3 Paint coat, when thoroly dry
4 Fill holes and depressions with asphaltic concrete.
5 2" Asphaltic concrete surface
6 Seal coat

Cross Section Showing Methods of Applying 2-In. Asphaltic Concrete.

On account of the fact that it is not necessary to use an excessive depth for an asphaltic wearing surface, drainage problems and surface conditions usually are met easily. The work of laying an asphaltic wearing surface can be done rapidly, and on important traffic thoroughfares the work may be carried out without excluding the traffic from the street, by simply laying the surface on one side of the street and confining the traffic on the other side. When the one side has been completed, the traffic is turned onto the finished pavement and the remainder of the street is surfaced.

Newsted Avenue, St. Louis, Mo.—Paved With 1½-In. Asphaltic Wearing Surface on a 1-In. Binder With An Old Brick Pavement As Base.

The method to be employed in doing the resurfacing is as follows: Adjust the old brick wearing surface along the gutters, street car tracks, around man-holes, valve stands, etc., in order to provide for the thickness of the wearing surface to be laid. After adjustments of the brick have been made, thoroughly clean the old brick surface, either by sweeping or by flushing, or by both sweeping and flushing. When the surface is thoroughly dry, apply a light paint coat of asphaltic cement and naphtha and allow it to set. Then apply a close binder of asphaltic concrete, filling all depressions and bringing the contour of the street to such shape as to allow a uniform thickness in wearing surface to be laid. After that, lay a wearing surface of either asphaltic concrete or sheet asphalt, at approximately 2 in. in finished thickness.

Cherry Street, Kansas City, Mo.—Paved in 1911 With Asphaltic Concrete Top Over An Old Brick Pavement As a Foundation. Photograph Taken May 19, 1919.

Many cities have adopted this method of treating their old brick streets and the results have been exceptionally satisfactory.

Four Definitions of Engineering

In its report presented Oct. 14 to the Board of Directors of the American Society of Civil Engineers the Committee on Development submitted the following definitions of engineering:

(a) Engineering is the science and art of directing the great sources of power in Nature to the use and convenience of man.

(b) Engineering is an art and science. It is a science in so far as physical laws are its base, and an art in so far as in the application of these laws the things designed and constructed develop the spirit of progress, the creation of wealth, and the well-being of all peoples.

Engineering is generally divided into four major divisions, viz., civil, mechanical, electrical, and mining.

The practice of engineering requires knowledge of physical laws, forces, and the materials of Nature.

The professional engineer is one who by reason of special training, education, and experience is qualified to design and direct the construction of engineering work in one or more of the major divisions of engineering.

(c) Engineering is the creative science and art of applying economically the materials and forces of Nature to the use and convenience of man.

(d) Engineering is the science of industrial effort, and the science and art of applying this effort for the welfare of the public.

An engineer is one versed in the science and art of industrial effort made for the purpose of public welfare.

The Membership Drive of the A. A. E.—The results of the membership drive held during December by the American Association of Engineers have been finally tabulated. Buffalo Chapter won first prize for clubs having a membership of more than 100 with an increase of 318.4 per cent. For the chapter or club having less than 100 members at the close of drive the Ogden (Utah) Club won first place with an increase of 209.09 per cent. The three members of the association obtaining the highest number of individual subscriptions were F. P. Obee, an engineer of Toledo, Ohio; J. W. Shera of Chicago; and Professor Samuel M. P. Dolan of the Oregon State College, who turned in respectively 131, 100, and 66 applications for membership. The membership of the American Association of Engineers at the close of business on December 31st was in excess of 10,400, and the determination of the association to obtain 10,000 members before 1920 has been achieved with a large margin to spare. There were almost 7,000 applications for membership received during the month of December.

The American Highway Problem*

By A. R. HIRST,

State Highway Engineer of Wisconsin.

We commence today, in this our annual meeting, what I sincerely feel is the most momentous highway gathering ever held in America. For the past few years the overwhelming shadow of the world war has hung over all our deliberations. Everything else was so secondary to the issues fought for and won in that great struggle that even those of us who most implicitly believed in the importance of highway work in America felt that highways and work upon them should be subordinated to the other and greater world purposes.

We did, however, fight and fight successfully in order that the great highway movement be not utterly crushed in the midst of the manifold demands of war, because we felt that by keeping together the nucleus of a highway organization, despite many short-sighted attacks, we were doing the American people a real service. It was not pleasant work, nor profitable, to those of us who were in the midst of the storm. But it was worth while and the fight was won, even though for a time the production of ukuleles was ruled by the powers that be as more important than the production of highways.

The New Era of Highway Construction.—But now all is changed. The American people, almost as one man, are demanding, and that instantly, a modern and comprehensive system of highways and are willing to pay the price. They have at last realized that the price of building highways which will serve the needs of the present and of the logically to be expected traffic is far less than the price they must pay if the present embargo of mud continues. Never, I believe, since the days of early railroad development have the American people been so determined to change instantly their means of transport and not even then were they so willing to pay the cost, provided they could get the results.

What are the results they are now demanding and what are some of the problems that grow from these demands?

They are expecting the states which had no highway organizations three or even two years ago, which had done no preliminary work and in some of which hardly a mile of modern rural highway had ever been built, to create an organization full sprung from the earth and to build instantly hundreds of miles of modern roads costing millions upon millions of dollars. In the older states in the highway game, better prepared with organizations and contractors, and with some knowledge of material and construction conditions they are asking us to double, triple or quadruple our annual output of roads. It is probably fair to estimate that the expenditure for modern highways in rural America in 1919 was about $200,000,000 and that the sum desired to be expended for them in 1920 exceeds $600,000,000. In other words, the people of America desire to approximately triple their highway expenditures and to do it in one year.

We are wont to think of the era of railroad building in America as presenting the greatest of engineering problems and that its solution was an astounding exhibition of the capacity of American engineering genius. However, the problem confronting American highway engineers today far exceeds the old one in magnitude. In the record five years of railroad development (1879 to 1883, inclusive) there were built 40,000 miles of railroad costing, as nearly as I can ascertain, about $20,000 a mile, on the average, or $800,000,000 in all. In the five years from 1920 to 1925, inclusive, the American highway engineer will be expected to build probably 100,000 miles of highway costing not less than $3,000,000,000. Even allowing for the depreciated dollar, the yardage of earth to be moved, the amount of materials to be furnished and transported, and the labor required is probably at least double that required in the former enterprise.

It may be of interest to list some of the tremendous problems facing the executives of state highway departments in this work of speeding up the national highway program to meet the American demand.

Trained Engineering Help.—This is a problem largely for American educators but with the present shortage and the very restricted output of young engineers, due to the war, it is an acute one demanding immediate attention. I might add that, in my opinion, a 4-year course is longer than is necessary for the preparation of much of the help that is needed, and a solution should be sought along the lines of the winter short courses of our agricultural colleges. We must have hundreds, yes thousands, of trained men at the earliest possible date and four or five years hence will not do.

Materials of Construction.—Nothing is more certain than that there will be an acute shortage of materials in 1920 and thereafter, unless there is substituted in place of the present hit and miss methods an intensive study of all available road materials in every state, and unless the most strenuous methods are used to develop every available source of supply. The extensive production and delivery of road materials during the winter season is going to be necessary, especially in the northern states with short construction seasons. Every state must establish a road materials department, the sole function of which will be to locate, test, develop, and arrange for the proper delivery of all available materials. Already there are rumors of combinations of material men to purchase and control all sources of highway materials. It is up to the states to protect their people by getting sufficient material sources in state and county hands before it is too late.

Cement.—It seems obvious that much, if not all of the so-called permanent surfacing will be either cement concrete or other surfacings on a cement concrete base, and that practically all drainage structures will be built of concrete. Unless there can be had the most absolute and fair federal control of the price of cement the bidding between municipalities and states and between contractors for cement is apt to drive the price up to the point of impossibility. In lack of federal control, the erection or purchase by the states of cement mills or state control of the output of certain mills would seem to be only a rudimentary conception of the duty of protecting the public against unduly inflated prices. The present unfair arrangement between manufacturers and dealers whereby dealers who never see or handle the cement must be paid hundreds of dollars for every mile of road built of concrete or with a concrete base must also be controlled effectively. States which buy millions of barrels of cement annually and pay always (no bad accounts) must get at least the dealer's price.

Car Service.—Car service has been execrable on practically every railroad. We have been handicapped day after day and month after month by the criminal neglect of the present railroad officials to recognize the fact that highway building is a great American industry. If construction is to be carried on with materials delivered by rail, better car service, and in the northern states, a longer season for shipments is necessary. Possibly the time will soon return when freight revenues will mean something to American railroads and when it will not be an insult to a railroad man to offer his company freight business. I sincerely hope so. Until then we ought not depend on materials involving a railroad haul except where no other source of supply is humanly possible. If the railroads are allowed to come out of their present state of coma and will give us the proper type of cars, enough of them, and reasonable service at fair prices in the installation of unloading sidings conveniently near the work, their revenues can be very materially increased, our costs decreased, and our work speeded up.

Who but a hopeless theorist could have devised the present system of railroad control wherein it's no one's business to get business, and the less business a railroad does the less the wear and tear on its roadbed and equipment and the greater it's real profit? If you guarantee a man a fixed income for a term of years, whether he does much, or little, or nothing, what is the inevitable result?

And yet it is seriously proposed to continue the present soporific arrangement, which has killed all railroad initiative, hamstrung all legitimate business and left us a nation with its primary circulatory system fitted with a tourniquet on every artery. The latest far-seeing exhibition of genius is the granting of time and a half for overtime on slow freights, whereby it is happily made possible for every freight train crew to greatly increase its earnings by making slower time!

Even in this railroad problem we must interest ourselves because we can never build our roads unless this American "sleeping beauty," our railroad system, is given an injection of dynamite and made to live again.

Efficient Construction Organizations and Fair Prices.—The contracting problem we always have with us. We need every competent highway builder available and we need to immediately multiply his number two to five times in the various states. We must encourage those good contractors who are now available and develop many new ones. To do this good prices will have to be paid and fair treatment given. On the other hand, we must not hand over our clients' pocketbooks to the contractors with the injunction "take what you think is right, but please return us the cover." Unless some restraint is exercised, with the amount of work there is to be done and with the universal feeling existing that "my road must be built no matter what it costs" prices will be driven up and up without regard to proper cost, values or profits.

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*Presidential address delivered Dec. 8, 1919, before the American Association of State Highway Officials, Louisville, Ky.

In this connection, it is my belief that each state should immediately develop a moderately large construction organization fully equipped to do a portion of all classes of its work. Then in case prices on certain work are extortionate, the work may be done by force account. This plan has the advantage of developing and training the nucleus of a larger day labor organization if one should later prove necessary. It also gives at all times a true index of the cost of various kinds of work on the basis of actual and recent state experience. We cannot know the actual cost of work unless we are actually in the construction game.

Every state has availed itself, I believe, of the offer of war equipment from the federal government. Large supplies of many things useful in highway work, especially motor trucks, have been or will be received. The organization of a proper department to receive, fit for use, and handle this equipment is no mean problem. The states should carefully consider whether this equipment should not be made the basis of building up a permanent thoroughly well-equipped day labor organization as a means of protecting itself now and in the years to come.

I also believe it necessary for adjoining states to cooperate with a view of keeping prices for work fair and uniform under the same conditions. If adjoining states are going to bid against each other the cost of work in all of them will be sent up to the prohibitive point without any ultimate advantage to any state. It should be possible for the states to get together on this matter. Costs are quite figurable for each job and with a uniform system of allowances for the use of machinery, profits, and contingencies it should be possible to put work in all states on an approximately equal basis of attractiveness. These allowances must be generous, because we must attract the best contractors, but they need not, and should not, be wasteful. This problem is the most acute of all our problems and should be given immediate and serious attention by every state. I can think of no way in which more millions can be unnecessarily spent in the next few years than by allowing unbridled and useless competition for contractors and materials to prevail between municipalities.

The Labor Problem.—We speak blithely of millions of dollars for the construction of thousands of miles of road. This program means men, far more men than have ever been employed in this work before. But men are scarce and other productive labor must not be raided. Our farms, our mines, our factories, and our mills must be allowed to produce largely and at a reasonable cost. We should not pay our labor, or allow such prices to contractors as will enable them to pay their labor, a sum per day greatly in excess of the going wage for like work in that vicinity. Whether we pay high prices for labor or whether the contractor does, it is our responsibility, because the prices we pay for work determines the prices which can be paid for labor. In other words, we must not bull the labor market to the disadvantage of other production. This is public work, its continuance depends upon the support of the whole public, and we must be careful not to alienate this support by forcing our work at undue prices, thus upsetting local labor situations. This policy is not only right from the standpoint of expediency, but is also economically sound.

Improved Location and Alignment.—We have, in the past, been too prone to build along the old established lines of highways. This has been the easy course and it has been taken. But the new traffic conditions are so different and so intense that in considering the construction of a main trunk highway all of the old governing considerations, such as saving the buying of new lands for right of way, utilizing old cuts and fills, saving an existing bridge or a few good culverts no longer bind us to the old locations. We must connect the centers of population because they are the points from which things and persons come and to which they wish to go. In building a modern highway between these fixed points we can feel free to exercise our untrammelled judgment and build where the road will ultimately cost the public the least. Shortness of distance, freedom from dangerous curves and from railroad grade crossings, and reasonable grades are now the principal ends to be sought and practically nothing else counts.

Cost of construction has become secondary. If the very conservative sum of 10 ct. per mile is allowed for each mile of travel saved, the saving of a mile in distance on highways carrying the following average number of vehicles per day will save the traveling public the given amount per year, which is the interest at 5 per cent on the amount given in the third column of the following table:

VALUE OF A MILE IN HIGHWAY DISTANCE SAVED.

Average number of Vehicles per day.	Saving to Owners per year.	Saving capitalized at 5% equals
100	$ 3,650	$ 73.000
250	9,125	182,500
500	18,250	365,000
750	27,375	547,500
1,000	36,500	730.000
2,000	73,000	1,460.000
5,000	182,500	3,650,000
10.000	365,000	7,300.000

I believe that these figures are unassailable and that they demonstrate that when building our main highways for all the years to come, saving in distance in the layouts is the supreme consideration and should be given much more attention.

Other Important Problems.—Many other important problems could me named and briefly commented on but this paper will be too long if continued along these lines. I cannot, however, resist naming without comment some of the other things with which an efficient state highway department must also concern itself:

A proper system of records of the cost of all construction and of accounting for all funds available.

Proper publicity of plans and results, not only in the local press, but in the national press.

Proper care of traffic during reconstruction.

Proper touring maps for the information of the people of the state and of other states.

Proper marking of the main traveled roads, keyed to the state maps.

Proper accommodations for the traveling public in the way of garages, hotels, public parking places, and comfort stations.

Complete knowledge and study of, and, if necessary, the design of labor and time saving devices and equipment.

A study of plant layouts and equipment for various types of construction under varying conditions.

A study of the grade crossing situation and a strong campaign for improved conditions.

The holding of road schools and short courses for the instruction and inspiration of all classes engaged in supervising and constructing highways.

Helping to formulate and pass adequate highway legislation so that the state may keep pace with other states.

The Coming Battle.—It may readily be seen from this hasty survey of some of the attendant problems that these changed highway conditions and this spirit of getting hitherto unheard of results have, instead of making our task easier, but served to tremendously increase our problems and responsibilities. We are on the threshold of a new epoch in highway construction in America, but instead of congratulating ourselves today that the long fight for highways is won, we should rather gird our loins for the impending battle. Added responsibilities bring added fears to the executive who thinks and spur him on to new efforts and new devices for developing himself and his organization to meet the new conditions.

The coming battle is all the more serious because from time immemorial the American people, while always willing to pay the price for the work they desire, have never been willing to pay the price of the proper supervision of it. "Millions for public works, but a pittance for those who must design and supervise the building of them" seems to be the American spirit. Our national and state legislative halls are filled with men who appropriate millions and tens of millions with very little thought of the organizations necessary to properly expend them, and with much less desire to provide proper supervision than to further the prestige of themselves or of their political party.

The Government a Niggardly Employer.—As a case in point: It was with the greatest difficulty that the present Congress could be induced to fix the salary of the very competent present head of the Federal Bureau of Roads at $6,000 a year, although this bureau will in the years 1919 to 1922, inclusive, supervise from the federal standpoint and protect the federal interests in the expenditure of probably $200,000,000 of federal money and with it the expenditure of $300,000,000 more from the states and local units. When a federal highway commission is proposed to be created to expend billions in the layout, construction, and maintenance of the proposed federal highway system, the salaries of the commissioners and of the chief engineers are fixed, under protest, at $10,000 each per year, and we are told that Congress will never stand for these salaries and that they will probably be cut to much less before the bill becomes a law, if it should become a law. The national Congress is probably the most niggardly employer in America, unless some of the states bear off the unenviable palm. It seems hopeless to expect a continuously efficient organization in any federal bureau unless Congress shall see a new light and fix public salaries to fit the imposed responsibilities.

It is interesting, although disconcerting, to note the almost total lack of interest on the part of road promoting organizations in the fundamental problem of getting proper administrative bodies to control the highway programs. We have good roads associations, trail associations, highway councils, etc., ad infinitum, all seeking to promote the construction of roads in detail or in mass, and urging the nation, the states, and the countries to spend millions or billions on highways of all kinds, classes, sorts, and conditions.

The sole idea seems to be to get money and more money to build highways. It does not appear to matter to them what kind of highways, who builds them, or whether the people get a dollar's worth or a dime's worth for a dollar. Men are in these associations who make millions every year, who control organizations which are solely designed to get efficient dollar for dollar results, and who pay their executives what they are worth. Yet when they get into the field of public service they seemingly forget all the rules which made their own business a success, and expect a thousand dollar man to be the eighth wonder of the world and world beating organizations to grow overnight with no possible financial encouragement. Unless business men of this class wake up and devote more thought to the basic problem of getting efficient organizations to spend the money, I fear a real disaster to our highway programs.

Politics and Salaries.—All of us have probably in the past derided the possibility of getting effective results out of town and county highway efforts because (we said) politics had too great a part in road work in those units and that they would never pay the salaries necessary to get competent planning and supervision of the work. And yet in 34 of the 48 states which now have state highway departments, the governor may change the personnel of the state highway department so as to control it during his term of office. In many of these states the highway law is deliberately so framed that a new governor may make a clean sweep of the state highway department the minute he assumes office, if he so desires. In most cases he seems to have desired it. There have been at least 127 different executive highway officials in these 34 politically organized state highway departments in the grand total of 296 years of their existence, or a change every 2⅓ years on the average in each state. The oldest executive officer in charge of highway work in any American state has served his state 9 years in that capacity.

A state highway department is not right or it is not wrong just because it has a republican or a democrat at its head, or because one brand of republican or democrat is in control when another brand of the same political party comes into power. A state highway department is right when it is well organized to get efficient and economical results and is wrong when it is organized or unorganized to produce inefficient and uneconomical results.

Let us consider the salaries paid the executive officers of the state highway departments. There is one who is paid $20,000 per annum; two, $10,000; one, $8,000; two, $7,000; two, $6,000; and eight $5,000; while thirty-two of them are paid less than $5,000, and twenty of them receive $3,600 or less. In this connection it should be remembered that the highway work expected to be supervised by a state highway department is now in few cases less than $3,000,000 a year and in many states it has reached, or will soon reach as much as fifteen, twenty, or twenty-five millions. What business organization in the world would pay on a similar scale for similar responsibilities or would expect to receive adequate results under such conditions?

I speak of these matters not in a spirit of fault finding but in order to interest you in the great problem of building up public opinion to the point where, for its own protection, it will insist upon the proper organization of every agency which deals with the expenditure of these great aggregations of highway funds.

Clean Cut Efficiency in Highway Administration.—We must, by every means in our power, by precept and example, preach the doctrine of clean cut business efficiency in American highway administration. In doing so we will go up against the age-long prejudice of the American people against paying their public servants a living or a proper wage. From top to bottom the scale of public salaries is wrong. The constitutional and other officers of the nation, of the states, of the counties, and of all other municipalities are, practically without exception, being paid, not on the basis of what their services are or should be worth, but on a basis fixed (in most cases long years ago) with due regard to the "honor" which must accrue to the holder of a public office. The universal custom was, is, and possibly always will be, to figure that the prospective holder of the job will be a politician with other interests or means and that the salary won't matter, or that joy at getting the "plum" of public office will dwarf all material considerations.

There is or should be an honor in being selected for public service—and worthy public servants appreciate and feel that honor. It may be, although I doubt it, worth while for the American people to consistently penalize those who work for them by paying them less than a living wage or less than the work would command if done for a corporation, or if done for the individual citizen in his private capacity. But the trouble with the system is that when the American people have before them a piece of really constructive work, like their present highway program, the policy falls down absolutely.

We must help the American people by making them realize that with hundreds of millions, even billions, to be expended in the next few years the building of highways is a profession and a business and not a political football to be kicked around like the proverbial pup. This is not selfishness. Most of us are in this highway business because we love the work and because we want to help build up the states and the nation. I doubt if there is one man here who has made good or who is capable of making good who cannot leave his present state position and make more money working for himself or in employment in commercial lines. But the work must go on and it must go on well and we must feel an interest above a mere financial interest in the jobs we hold, if we are worthy of them.

Money is not all—the satisfaction of creating, of building; of creating and building well; of helping to build a county, a state, or a nation, is worth more than a few hundred or a few thousand dollars a year if one can manage to live. We can't afford to pinch pennies and bandy words just for ourselves, but in the interest of the competent and "up and coming" highway organization which must be created in every state to protect the interests of the people of the state, we can afford to fight for the right.

Unless there occurs a radical change in the American spirit of expecting much from their public servants and giving little, not one of us here will ever get rich or even attain a competence in the public service. We will, on the contrary, fight on and on until disgruntled politicians finally get us, or a younger and better qualified man supplants us. With the best of our youth, our enthusiasm, and our strength gone, we will retire full of wounds, without money, and without honors to make a new start in middle age. Such is the almost inevitable fate of the servants of the American people. But we can retire with honor unsullied and with our flags still flying. Later those who now fight the good fight for right standards and thus help make the path of their successors easy, may be recognized as public benefactors. When these pioneers are dead and buried, as is the custom here, they will be acclaimed as, after all, worth while and possibly even monuments will be erected to some of them.

I trust that nothing I have said in regard to state highway organizations will be wrongly construed. The present organizations, with very few exceptions, are, and have been doing effective work with limited opportunities. Where there is trouble it is in most cases due principally to the damnable political obsession of our American commonwealths. In too many states it is not even debated that the old political motto "to the victor belongs the spoils" is the law and the gospel, and the idea that the victory of any political party or of a faction of any political party should not carry with it the transfer of all offices within the governor's control is not even considered, but a total overturn is taken as a matter of course. County and state officials without number have been thrown out of office for no other reason than that "they have held the job long enough, someone else should be given a chance." If a bank or a railroad, or any other corporation adopted the idea that political belief was the hall mark of efficiency or that long continued service was a valid reason for discharging their personnel, public confidence would be lost, their stocks would be a drug on the market and the corporation itself would become bankrupt.

In fairness to my home state, Wisconsin, it should be stated that we have a non-political highway commission, the operations of which have been entirely free from political interference by the governor or anyone else. I state this because there may be some idea that my remarks originate from dissatisfaction with conditions in my own state, which is not the case. Conditions, laws and public sentiment there are good and improving fast. I have, however, long been a student of American highway administration, have followed changing state laws and personnels, and have attended practically all national highway meetings for years. As a result of these observations I believe I can safely say that the great American highway problem will never be solved rightly until we get our state and county organizations safely established on the sole basis of well paid efficiency.

The American public must be convinced that if they will play politics with their public officials they should confine themselves to routine offices where almost anybody can get by because someone else does the work anyway. They must be convinced, on the other hand, that the highway departments of the states and of the counties come into a different class and that here merit and knowledge should be the sole criterion in selecting and keeping their officials, and that here at least, length of training and service is of tremendous value and a necessity if efficient and economical results are to be secured.

The professions of highway engineering and of highway building must be dignified so that they attract the best engineers and the best construction men in America. This is important not only for the immediate future, but especially so for the years to come. Not only must we strive to attract and keep the best we have but we must get the coming men. We need all the brains and all the talent we can muster. To attract the best young men good working conditions, a clean atmosphere in public service, adequate compensation, and a reasonable chance of advancement must be offered. Less than this will not serve.

Therefore, let us dedicate ourselves to this work of helping to make all highway organizations efficient instruments, able and competent to carry out the American purpose of building a highway system befitting the greatness of the American nation. Than this, we can do the American people no greater service.

Motor Flushers at Ottawa Save $12,000 in 1 Year.—Each of the motor street flushers of Ottawa, Ont., has replaced 10 horse-drawn outfits, according to the report of the Works Commissioner of that city. He states that two 1,000-gal. power flushers mounted on 3½-ton trucks operated all year, flushing an average of 18 miles of pavement, of all widths per day at a cost of $1.72 per mile. The total cost was $4,650 for 150 days of actual operation. The teams formerly used accomplished this work for $16,800.

Mechanical Equipment Saves Cost of Ten Men on Concrete Road Job

Use of mechanical equipment on concrete road work on the Hope-Bridgeville road in Warren County, New Jersey, resulted in a considerable saving in labor and contributed largely to superior workmanship, according to an article by H. W. Vetter, County Engineer, in the December Concrete Highway Magazine.

A mixer loader was employed in charging the skip and a finishing machine followed the mixer and completed the pavement. Use of the mechanical loader resulted in saving about six men, and the finishing machine eliminated four.

Aggregates were secured from local sources. Sand was well graded and washed before used. Coarse aggregate was a dolomitic limestone of excellent quality. Grading was from 2 in. downward. Sand and stone were piled alternately on one side of the subgrade, requirements of each being very closely estimated. The loading machine ran alongside the material piles and was loaded from one side only. Adjustable hoppers on the loader were filled and struck off to the right capacity. Two men handling the sand and six handling the stone into hoppers of the belt conveyor kept the material going into the mixer at such a rate as to lay 425 sq. yd. of 6-in. pavement in a day's run of 9 hours. In the opinion of the superintendent in charge, there was an actual net saving of the cost of six men.

Mixer Loader Employed on Hope-Bridgeville Concrete Road Job.

A finishing machine was used for striking, tamping and belt finishing, and handled a stiff mix of concrete. The machine produced an exceptionally dense concrete with an unusual uniformity of surface. Joint filler was placed with care and the tamping board of the machine was brought right up to the joint. It was then raised over the filler and continues work on the other side. Final finishing at the joints was done with a split float. The leveling on each side of the joint was done with a straightedge notched in the center, to fit over the joint. Since one man operates the machine and two men place material, there was a net saving of about four men in the finishing operations.

In curing the finished pavement a 3 to 4-in. straw covering was placed and kept wet by sprinkling for ten days. This method proved entirely satisfactory.

Two Compartment Truck Bodies Carrying Concrete Aggregate.—An interesting method for transporting aggregate to the mixer was employed by the G. V. Stack Construction Co., Denver, Colo., on its 10-mile concrete highway contract in Sheridan County, Wyoming. After being loaded into 5-ton trucks from bins at the screening plant, aggregates were carried to stock piles placed every 1,000 ft. along the right of way. From these piles they were loaded by hand into Ford trucks, each of which was equipped with a double compartment body, containing a longitudinal division board. The trucks have a capacity of 8 cu. ft. of sand and 12 cu. ft. of pebbles. Cement was added to the sand compartment at the stock pile and the truck load carried and dumped into the skip of a 24 cu. ft. capacity mixer.

Summary of Highway Construction Conditions in Various States

Papers reviewing the highway situation in various sections of the country were presented on Dec. 8 at the annual convention of the American Association of State Highway Officials. The papers contained interesting information on the construction progress in 1919 and the outlook for 1920, and also on the labor and material situation and recent legislation. Three of the papers are given in abstract below.

Conditions in the New England States.

By COL. WM. D. SOHIER,

Formerly Chairman Massachusetts Highway Commission.

Miles of Highway Constructed and Maintained in 1919.—During the year 1919 there were approximately 300 miles of state highway constructed in the New England states, at a cost of about $2,300,000, and 228 miles of state aid road constructed at a cost of about $2,700,000.

There were approximately 15,500 miles of road maintained by the states or under state supervision, either state highways or state aid roads. Figures for Connecticut are not available but $4,300,000 was spent on this maintenance and reconstruction work in the other five states.

There were 515 patrolmen employed in Maine and from 300 to 600 per day in Massachusettes, not including 400 town employes who actually did maintenance work.

The following table summarizes the expenditures in 1919:

State.	Miles maintained.	Cost of maintenance and reconstruction.	Miles of State Highway and State Aid constructed.	Cost
Maine	4,400	$ 700,000	145	$1,500,000
New Hampshire	1,425	750,000	120	....
Vermont	1,518	98,670	115	412,000
Massachusetts—				
State Highway and State Aid	2,286	2,211,000	...	....
73 towns	4,000	225,000	140	2,400,000
Rhode Island	333	1,000,000	...	....
Connecticut	1,627	....	...	....
	15,589	$4,984,670	520	$4,312,000

Maine has voted 5 to 1 in favor of authorizing the state to issue $8,000,000 in bonds to be used in constructing state highways and state aid roads, also to meet federal aid of which she secures $2,648,000.

Money Available and Work to Be Done in 1920.—The amounts that probably will be available in the various states during 1920 are shown in the following tabulation:

State.	Miles of state highway construction and reconstruction.	Cost.	Miles maintained.	Cost.
Maine	150	$4,500,000	4,500	$ 800,000
State Aid	100-125	1,250,000	.....	....
New Hampshire	100	1,250,000	1,500	750,000
Vermont	75	1,323,000	1,518	98,670
Massachusetts—				
State Highway and Federal Aid	100-125	3,300,000	2,286	1,200,000
State Aid	100	1,500,000	.....	....
Reconstruction	60	1,250,000	.....	....
Poor town roads	...	....	5,500	450,000
Rhode Island	30-40	1,300,000	333	350,000
Connecticut, av. 2 years	140*	3,845,000	1,627	....
	855-915	$19,518,000	17,264	$3,648,670

*Estimated.

Conditions in Central Western States.

By F. R. WHITE,

Chief Engineer, Iowa State Highway Commission.

This summary of the highway situation covers nine states, as follows: North Dakota, South Dakota, Nebraska, Kansas, Missouri, Minnesota, Wisconsin, Illinois and Iowa.

Mileage of Work Contracted or Placed Under Construction in 1919.—During the past year, the several states of this group placed under contract approximately 7,400 miles of road. On nearly 75 per cent of this amount, or approximately 5,000 miles, the improvement proposed consisted of construcing the roads to finished grades and providing the necessary drainage, but did not contemplate paving or other form of surfacing. On approximately 1,400 miles, the improvement consisted of graveling or other similar form of surfacing. On the remaining portion, or about 1,000 miles, the improvement contemplated the construction of pavement. Illinois leads the list in mileage of pavement contracted, with approximately 575 miles. Wisconsin is second. In some of the states very little paving was contracted.

The approximate total cost of the work contracted or placed under construction, was $48,000,000.

In none of the states was the program of construction outlined for 1919, completed. The amount of work completed ranges from 20 to 85 per cent of the work contracted or placed under construction, the average being about 53 per cent. It will thus be seen that the Central Western states will carry over into 1920 a considerable amount of uncompleted work. This uncompleted work added to the program outlined for the year 1920, will make the accomplishment of the program for that year all the more difficult.

Conditions as to Prices and Supplies of Labor and Materials in 1919.—One state, North Dakota, reports the supply of labor in 1919 better than in 1918. The prices, however, were 60 to 100 per cent higher than in 1918. One other state, Illinois, reports that labor was fairly plentiful, but very independent, and, therefore, inefficient and not dependable. All the other states report a scarcity of labor during at least a portion of the year. In some states this scarcity was very pronounced. The prices of common labor varied from 35 to 60 ct. an hour. The prices of teams varied from 60 ct. to $1 per hour. As illustrating some of the difficulties with which the contractors have had to contend, one of the states reports that labor increased from 40 ct. at the beginning of the season, to 52 ct. at the end of the season, while teams increased from 80 ct. at the beginning of the season to $1 at the end, an increase of 25 per cent to 30 per cent in labor and team costs.

Apparently in the majority of the states a sufficient supply of materials has been available. The main difficulty has been to get the materials transported from the point of production to the construction operations. In a number of the states, there was a rise in the price of materials towards the close of the season, due no doubt, to the poor transportation facilities which tended to restrict the available supply.

Actual New or Proposed New State Legislation of Especial Interest.—North Dakota: Special session of the legislature now in session. A bill has been introduced to amend the constitution so that the state may issue $50,000,000 in bonds for road purposes.

South Dakota: It is expected that new legislation will be enacted, making it easier to authorize hard surfacing road projects.

Nebraska: A new law which takes effect January 1, 1920, creates a state highway system of 4,500 miles and an automobile license fund of $2,500,000 for maintenance.

Kansas: A number of minor changes were made in the road laws to permit a better operation thereof. Also, more stringent regulations were provided for the elimination of railroad crossings. The most important piece of legislation was the submission to a vote of the people, of a constitutional amendment for state aid in the construction of highways.

Missouri: A law was passed at the last session of the legislature, giving more authority to the state highway department in the making of surveys and the preparation of plans for road construction.

Minnesota: New legislation proposed consists of an amendment to the constitution, providing for the construction of a trunk line system of highways of approximately 7,000 miles.

Wisconsin: State laws were amended so that the cost of surveys and right of way on federal aid projects can be charged to the project, thus very materially relieving the state highway department's administration fund. A new law was passed providing that advertising signs along the highways shall be removed.

Illinois: A new law was passed limiting the maximum axle loads permitted on any motor propelled vehicles to 8 tons. This law also places motor trucks and similar vehicles in a separate classification as regards license fees, the character of tires, etc. A law went into effect July 1st, requiring that all highway bridges built in the state and costing over $200, shall be subject to the approval of the county engineer, who is a deputy of the state highway department. Another law provides that all bridges built in the state must conform to the structural requirements of the state highway department.

Iowa. A new law was passed creating a primary road system of approximately 6,000 miles, providing for the construction and maintenance of such system, creating an annual fund therefor, and providing for the issuance of bonds in anticipation of such fund. The motor vehicle law was revised and the registration fees increased, so that it is anticipated that this law will produce approximately $8,000,000 annually, which fund will be used in connection with federal aid in the improvement of the primary road system.

It will be noted from this brief summary of legislation, that the trend is very strongly towards an enlargement of the program of highway construction, making provision for better types of roads, providing funds therefor, and placing more power in the hands of the state highway departments. The tendency also in this section is very strongly towards placing the major costs of a trunk line highway system on the motor vehicle rather than on real property.

One bit of legislation to which I would call special interest is that reported by Wisconsin, with reference to the removing of signs along the highways. Personally, I do not see the necessity of permitting our highways to be lined up with every kind of advertising sign as is now the case in most states. These signs, in addition to their generally unsightly appearance, often render the highways dangerous by cutting off the view at sharp turns. I hope to see the day when such signs will have entirely disappeared from our public highways.

State and County Bond Issues Passed and Pending.—Approximately $462,000,000 in bond issues have been passed or are now proposed. Of this amount, $138,000,000 worth of bonds have been authorized. Principal of these is the $60,000,000 bond issue authorized by the state of Illinois, none of which has yet been expended. The next largest bond issue authorized is in the state of Iowa, where 13 counties have voted $18,500,000 in bonds.

Approximately $324,000,000 in bond issues are proposed. Principal among the state bond issues proposed is the $100,000,000 bond issue proposed in the state of Minnesota. Wisconsin stands first in the county bond issues proposed, these proposals running between $50,000,000 and $60,000,000.

Considering the vast amount of bonds passed and the still greater amount proposed, it is apparent that the difficulty of the state highway departments of the central western states has shifted from one of finances to one of construction. It appears safe to say that no state highway department will be able, within the next two or three years, to spend the funds that are now actually available, or that it seems very probable will be made available in the near future.

Proposed Mileage of Construction and Probable Expenditures in 1920.—It is rather early in the season for the state highway departments to give a definite statement of the mileage of each type of road proposed to be constructed during the coming year. Also, from the way prices have been jumping, it is difficult to give an estimate with any degree of accuracy, as to what the cost of the work will be. Reports indicate that approximately 9,500 miles are included in the programs of the several states included in this group. Probably 60 to 75 per cent of this mileage will be improved by grading and draining only. The probable cost of this work will be in the neighborhood of $102,000,000. These figures include only the primary, state, or trunk line highway programs. They do not include the construction or maintenance work which will be done by the various counties and townships. From experience in the state of Iowa as to the volume of expenditures by the counties and townships, it seems safe to say that at least another $100,000,000 will be spent on county and township work.

Anticipated Conditions as to Prices and Supplies of Labor and Materials in 1920.—It is anticipated that prices during 1920 will be at least as high and possibly 10 to 20 per cent in excess of those prevailing in 1919. It is anticipated that the supply of labor will be about the same as in 1919. In some places there will be a shortage of labor, while in other places there will be a reasonably plentiful supply of labor, but it is expected to be independent and inefficient. The question of materials depends largely upon the railroad situation. It is believed that if assurance could be had that railroad facilities can be provided, additional capital would be interested and the supply of materials would be assured. With the present very great uncertainty with reference to rail transportation, it cannot be expected that there will be a very great extension in the production of materials or in the capital invested therein. In order to avoid the very acute shortage of rail transportation facilities, many of the states are using every effort to produce materials locally.

Since the reports on which this brief summary is based, were made, the situation with reference to the coal strike has become acute. The reports, no doubt, were written without giving the coal strike serious consideration. What may yet develop from the coal strike remains to be seen, but certain it is that this strike will not relieve the serious conditions of the railroads nor materially improve the difficulties with which highway officials will have to contend next year.

Conditions in Southern States.

By W. S. KELLER,

State Highway Engineer of Alabama.

Questionnaires were mailed to North Carolina, South Carolina, Tennessee, Arkansas, Louisiana, Mississippi, Florida, Georgia and Alabama. Replies were received from all of the states with the exception of North Carolina and Louisiana.

Approximate Mileage and Expenditure for Construction in 1919.—Arkansas: This mileage and cost cannot be divided upon a yearly basis.

Georgia: Two hundred miles constructed with an expenditure of $2,500,000.

South Carolina: Ninety miles with two bridges completed and five others under construction. Total cost for work done this year (estimated) about $1,100,000.

Tennessee: Federal aid, 67.8 miles, to cost $854,837; state aid, 38.66 miles, to cost $209,153.

Alabama: One hundred miles, to cost $600,000.

As a large number of contracts extend from one year into the next and are in various stages of construction it is manifestly impossible for a state to give accurate approximation of miles of road constructed and expenditures for the year.

Conditions as to Prices and Supply of Labor and Materials in 1919.—Arkansas. Prices very high for both labor and materials, freight rates high. Labor scarce and inefficient.

Georgia: Convict labor scarce. Free labor plentiful at $3.50 per day. Materials plentiful at source of supply but scarce and expensive because of lack of transportation and high freight rates.

South Carolina: About 2¼ times that of 1916.

Tennessee: Materials satisfactory; labor and transportation the problems.

Alabama: Prices very high with labor hard to get and very unsatisfactory.

Actual New or Proposed New State Legislation of Especial Interest.—Arkansas: The 1919 legislature in regular and special session created special road improvement districts to build more than 6,000 miles of good roads.

Georgia: An act of Georgia legislature, approved Aug. 18, 1919, reorganizing the state highway department; and an act approved Aug. 16, 1919, amending "Georgia Motor Vehicle Law," which will provide approximately $2,000,000 per annum for highway construction and to liquidate the bonded indebtedness which, by vote of the people of Georgia, may be created to build and maintain roads of this state.

South Carolina: Proposed doubling of auto tax which will raise about $1,250,000 and a 2 mill tax which would raise about $750,000.

Alabama: A new state highway bill was passed by the legislature in September enlarging the power and authority of the state highway commission and increasing the state appropriation. There was also passed a bill authorizing a vote of the people, election to be held next February, to amend the state constitution so that $25,000,000 in state road bonds may be issued. If passed favorably the law becomes self-acting and will be immediately put into effect.

State or County Bond Issues Passed or Pending.—Arkansas: No state or county bonds can be voted in Arkansas.

Georgia: Counties have voted $17,000,000 in bonds. Issue of $40,000,000 in bonds by state pending.

South Carolina: No state bond issues. Previous county and township bond issues totaling about $7,250,000. Proposed county bond issues about $3,000,000.

Tennessee: County bond issues, $11,832,250.

Alabama: One county has voted a bond issue of $150,000, the proceeds to be used in conjunction with state and federal aid. A constitutional provision prevents any county from having a bonded indebtedness greater than 3½ per cent of its tax valuation. Most of the Alabama counties are up to this small debt limit.

Proposed Mileage of Construction and Probable Expenditures in 1920.—Georgia: Proposed mileage of construction in 1920, 400 miles with an approximate expenditure of $6,000,000. South Carolina: Four hundred miles and about $4,000,000.

Tennessee: One hundred and eighty-nine miles bituminous road at an estimated cost of $25,000. and 427 miles waterbound macadam at $16,500

All these projects are under survey and will be in shape for contract by spring.

Alabama: If bond issue fails $1,000,000 will be spent. If bond issue is successful the expenditure will be $2,000,000. These amounts are exclusive of federal and county funds.

Anticipated Conditions as to Prices and Supply of Labor and Materials in 1920.—Arkansas: In view of large amount of work contemplated, scarcity of contractors and men, car shortage, lack of local materials, etc., I think prices will remain high.

Georgia: It is anticipated that convict labor will diminish. Price of free labor and materials will remain the same but supply will be deficient.

South Carolina: About same as 1919. No material change anticipated.

Alabama: Do not look for any change

Gravel Plant and Small Truck Hauling Outfit for Paving Job

In order to be certain of having a steady, dependable source of supply of sand and gravel for a large pavement contract at Esthervile, Ia., that had to be completed within a time limit, the Des Moines Asphalt Paving Co. of Des Moines, Ia., bought a partly worked gravel pit adjacent to the job, installed the necessary gravel-handling equipment and operated a small fleet of light motor trucks to transport the aggregate from the pit to the concrete mixer.

The pit which was taken over by the contractor had been worked with pick and shovel for local wagon trade. It was located ½ mile from the paving work and the average haul for the entire job was less than three miles. Thus it was possible to keep the mixer constantly supplied with materials without employing an excessive number of trucks. The success of this ingenious scheme was further assisted by the fact that the gravel deposit contained a grade of material so uniform and free from faulty composition that it could be used practically in its natural state as aggregate for the concrete.

The requirements of the work called for approximately 200 cu. yd. of aggregate per day. To meet these requirements the 300 ft. span, ½ cu. yd. Sauerman dragline cableway excavator illustrated in Fig. 1, was installed. This machine excavated and conveyed the sand and gravel to the bin, where the material was measured into trucks after passing through grizzly bars to take out the over-size stones.

The motor trucks were equipped with Lee end dump bodies The trucks carried 1 cu. yd. of sand and gravel and three bags of cement each trip. The aggregate was dumped directly into the charging skip of the mixer as shown in Fig. 2

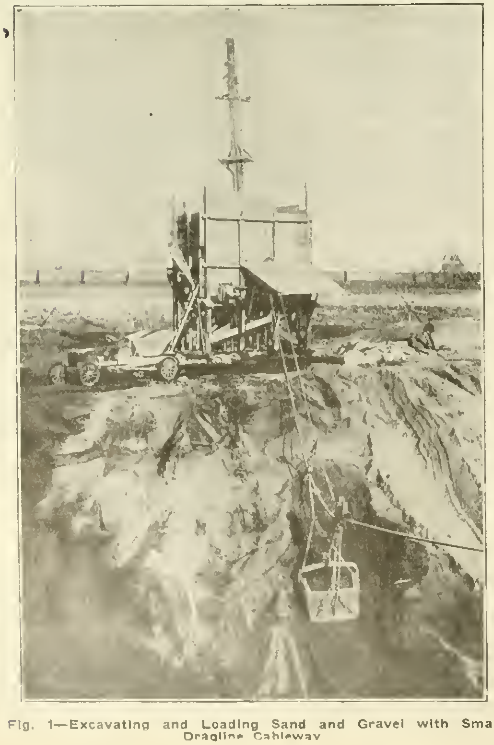
Fig. 1—Excavating and Loading Sand and Gravel with Small Dragline Cableway

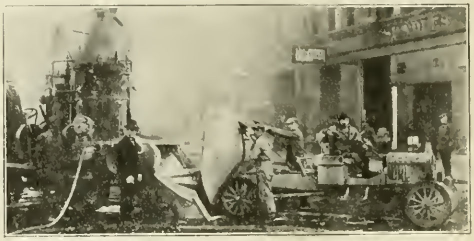
Fig. 2—Dumping Charge Into Mixer Skip.

Analysis of Costs of Motor Bus Operations.—The Commissioner of Plant and Structures of New York City recently submitted to the Board of Estimate an interesting analysis of the costs of motor bus operation. The proposal was for a permanent municipally-operated system of bus lines. The report shows that 100 buses operating on a 5-ct. fare basis can be made to pay a profit of $376.80 a day. The cost of 100 buses is figured at $550,000, spare parts at $10,000 and garage equipment at $10,000, a total investment of $570,000. For maintenance, the estimate provides $635,000 yearly, covering liability at $500 per bus, garage cost at $250 per bus, and 180 chauffeurs at $1,800 a year. Depreciation is figured at 30 per cent a year on buses and 10 per cent a year on other equipment. These items, together with provisions for a superintendent, starters, and checkers, totals $17.40 per day for each bus. For running cost, 4 ct. a mile is allowed for gasoline and oil, 6½ ct. for tires, and 1½ ct. for repairs, a total of 12 ct. per mile. The plan contemplates the operation of 92 buses, eight being kept for breakdown service. At an average of 80 miles a day per bus, the total "bus miles per day" will be 7,360, which, with the fixed charges brings the total cost of operation to $2,623.20. At the conservative estimate of 60,000 5-ct. fares, or a total revenue of $3,000 a day, the net daily profits are figured at $376.80. The estimate does not include interest on the investment, insurance, other than liability, or state motor vehicle license fees.

Street Cleaning Costs in Chicago.—In 1918 2,711,799,254 sq yd. of streets were cleaned in Chicago by the block and gang system, the work involving the collection and removal of 405,912 cu. yd. of street dirt. The cost of the cleaning, according to last annual report of the Department of Public Works, was 38.8 per 1,000 sq. yd. or 46 ct. per capita. In the same period 46,306,613 sq. yd. of streets were cleaned by horse-drawn flushers at a cost of $9,700 or 20.9 ct. per 1,000 sq. yd. The flushing required 17,932,200 gal. or 23,633 tanks of water. Street cleaning with auto flushers was done at a cost of 12 ct. per 1,000 sq. yd. In this work 54,587,365 sq. yd. were cleaned, 15,215,500 gal. of water or 13,856 tanks being used. The cost in detail was:

Expense, drivers and helpers	$2,723.99
Gasoline, oil, etc.	1,465.26
Auto parts and repairs	2,500.00
Total	$6,689.25

Some Items a Paving Contractor Has to Cover in His Bid

In a paper presented at the last annual meeting of the League of Iowa Municipalities, Mr. M. G. Hall, Consulting Engineer, gave some interesting information on the overhead costs of the public works contractor. We quote from his paper as follows:

I wonder, if in public works, we always recognize the items of cost that a public contractor has to cover in his bid if he is to make any money after all bills are paid. I have tried for the purpose of this paper to get at some of these items in my own way and by taking the matter up with some of the larger paving contractors and I have found that there were some things which entered materially into the cost of such work which I had not recognized before.

While it may be true that some of the things I am going to mention are not applicable to all kinds of pavement and some possibly should not be charged at all, still there are a good many which are legitimate as items if properly applied.

This is a subject in itself and I will not go into detail but will merely mention some of the items which contractors claim are legitimate charges against public work and included in a bid for the same. I do not wish to start any argument on these points but merely to point out the same and we will all agree that several of the items are fair charges. The chief difficulty arises in trying to make the proper allowance for them.

One contractor says: "The conditions entering into each contract are so different that I would hesitate to give you a hypothetical case. The matter of financing is often a local problem as is also the discount on paper. Public liability and compensation insurance and rate on bonds are practically uniform costs. General office expense is apportioned over the amount of work done during the year. Depreciation, obsolescence, interest charges and equipment charges are items which are rather difficult to determine in view of changing labor conditions, the length of time required to complete a contract and the changing that is continually taking place in the form of equipment and method of operation. The best example I can give of this is the radical change in the manner of feeding concrete mixer with Fords instead of wheel-barrows. The cost of repairs can only be guessed at, although you can use your experience tables to cover old style equipment, but with every Tom, Dick and Harry driving your Ford cars who can tell what it will cost to keep them in shape."

Another contractor lists the following as, contractor's charges against a paving job:

"1. Main office expense including salaries of officers and office help.

"2. General expense.

"3. Interest on investment.

"4. Interest on borrowed money to carry job.

"5. Discount on tax certificates or bonds.

"6. Premium on bonds; construction $10 per M., maintenance $2 per year per M.

"7. Depreciation on equipment.

"8. Liability insurance (fire, public and workmen 10 to 15 cents per square yard).

"9. Idle time.

"10. Repairs on equipment.

"11. Charity.

"12. Procuring labor.

"13. Rent and leases on particular works."

Still another contractor says:

"I have checked over our machinery here, figuring it at the price we paid for it, and with what we had on hand, we have about $70,000 invested in equipment on this job. I would think that the upkeep on such machinery when it is new, the first year would run about 10 per cent and possibly 10 per cent the second year, but after that it would probably double. It all depends upon how machinery is taken care of, as to how long it will last, as, of course, you know. We aim to charge equipment off as worthless in about six years, if it is well kept up. Of course, you understand a steam roller well kept up, and an asphalt plant well kept up, will last quite a lot longer, but then again, other equipment would not last that long, so it would about average.

"You can readily figure the interest on capital invested to do a job, as you know a contractor does not get his money until the work is completed, so you have to figure 7 per cent interest and 3 per cent discount. The rates are a little higher this year, on account of there being plenty of work and they can get plenty of paper and are not fighting for business.

"Construction bonds cost 1 per cent of the entire cost of a job—maintenance bonds 1 per cent for over two years maintenance, of the entire cost; public liability costs $1 on the hundred on the pay roll and labor liability costs about $1.70 on the hundred.

"In figuring a job, based upon about $3 per square yard, we figure bonds, that is, maintenance and construction, public liability and labor, at about 10 to 11 ct. per square yard discount and interest will run about 15 ct. per square yard. Overhead is an item that we all have been fooled on this year, inasmuch as the increases in everything have been much more than we figured, about 25 ct. per square yard overhead which nowadays is very low. I would think overhead would run about 45 ct. per square yard.

"I believe the items I have given you pretty well cover most of your questions. . . . Overhead is surely an item —for instance, we had a crane and mixer shipped on the 18th of July. We just received them last week. When we knew we had a chance of getting them here, we had stone and sand ordered from various producing companies, some of which has been on the road for 20 days. We are now shut down, waiting for materials, at an overhead of about $100 per day, so when people figure on work, they do not want to take into consideration material costs and not appreciate expenses they do not see, which are beyond the contractors control. Most all contractors have met with many disappointments this year.

"Under the unsettled conditions of the present time it is not surprising that no long chances are being taken by the public contractor but it is to be hoped that order will soon come out of the turmoil of the present day and that stable conditions will be brought about so that the work can be done on closer margins than have been offered this year."

The following as given by one contractor is probably a fair estimate of the approximate cost of a paving plant to lay 100,000 sq. yd. yer year of asphalt pavement which also shows the annual depreciation charges to charge against the pavement done with the plant:

Asphalt plant	$15,000	10%	$1,500
Concrete mixer	4,000	25	1,000
Auto crane	6,000	25	1,500
Portable bins	1,000	25	250
6 auto trucks	6,000	25	1,500
10 wagons	2,020	25	505
10 teams	5,000	25	1,250
1 small mixer	1,500	25	375
10 asphalt wagons	2,000	25	400
Roller	5,000	15	750
Miscellaneous small tools	3,500	50	1,750
Total	$51,020		$10,780

Corrugated Paper Spacer for Wood Block Paving in Street Railway Track

A new method of laying wood block pavement in the track allowance of a street railway was used at St. Thomas, Ontario according to The Canadian Engineer. The old pavement was brick, on a sand cushion. When it recently became necessary to replace the worn rails, it was decided to repave at the same time with wood block.

The concrete base which surrounds and covers the ties was brought up so that when the wood blocks are laid on it they are flush with the top of rail. Instead of laying the blocks on a sand cushion, the smooth concrete base is given a paint coat of paving pitch (145° melting point, cube-in-water method) and the blocks are laid on this pitch piant coat as soon as it has hardened. Hardening takes only a few moments.

The rows of blocks are separated from each other by strips of corrugated paper 1¼ in. wide by 3/16 in. thick. The joints are therefore about 3/16 in. wide, or less if the blocks are lightly rammed. The joints so formed are then filled to about one-half their depth with coal tar pitch, and the remainder of the joint is swept full of clean sand.

The spacer of corrugated cardboard was used for the first time in June, 1919, in Bridgeport, Conn., in the track allowance of the Connecticut Co. St. Thomas is the first Canadian city to use it.

A strip of bitumized felt is laid along the web of the rail. Paving pitch is poured around this so as to waterproof the pavement from rail to rail.

Influence of Fair Specifications and Competent Inspection on Bidding Prices*

By H. S. MATTIMORE,
Engineer of Tests, Pennsylvania State Highway Department.

There are many serious problems confronting highway officials at the present time. One of the main factors on which the accomplishment of this work depends is the securing of large reputable contractors to undertake construction of these highways. It is a pure business proposition with these companies, and there is no reason why they will not seek it providing the highway officials make it attractive. This does not necessarily mean exorbitant prices. Fair prices with fair treatment, and intelligent clear specifications with competent enforcement generally prove to be a greater incentive than high prices and extensive delays, caused by incompetent inspection, indecision, and indefinite specifications.

With very few exceptions, the modern contractor is a big business man anxious to do good work and maintain friendly relations and thereby establish a good reputation. On the other hand, engineers are fairminded, or at least try to be, and their decisions are influenced only from the standpoint of obtaining what in their judgment is a good quality of work.

Now the causes of conflicts between the engineers and contractors are many and varied, but broadly they can be summed up as a difference in viewpoint. This is bound to exist, so long as individuals are of different character and mind, and in fact the stronger the character the more the argument necessary to change the viewpoint. Do not confuse this with ignorant stubbornness. We must be broad enough to realize that there are many problems in highway work that have more than one correct solution.

All Specifications Must Be Clear.—The highway official has full power to specify the character of work that the contractor must perform, and in justice to the state he must see that this work is performed according to these specifications. Now in my mind this is the source of many of the troubles arising during the progress of the work. The contract is taken by the contractor and he agrees to perform the necessary work in accordance with certain specifications. These specifications are written by the engineers and supposedly understood by the contractor. Now, is this latter always the case? Are all specifications clear? As an answer, consult articles in current numbers of engineering and contracting journals, also examine court records of state versus contractor on highway cases. In the latter you will find judge, jury and many legal authorities are trying to interpret various clauses in specifications. This, in itself, should convince us that the specifications must be clear. Make them concise if possible, but do not sacrifice clearness.

There is much to be said regarding specifications. In the first place, they must not be a product of one mind. A real clear and concise specification, if written, by an individual, should be done so only after ideas are obtained from men directly connected with the details of construction. Good practice must be adhered to and all methods must be described as definitely as possible.

Do not specify better quality or more detail than you expect to obtain. We have all seen specifications with many paragraphs or phrases, which were apparently written to act as a club over the contractor. They were supposedly intended as an insurance against a dishonest contractor. Such an insurance leads to high bids, and large reputable contracting companies will hesitate before bidding under such specifications, and when they do bid it will be high enough to play safe.

"To the Satisfaction of the Engineer."—Occasionally another type of specification is encountered which is so open and broad that it is dangerous. I refer to specifications, which, instead of definitely specifying qualities and describing methods, will call for work being done satisfactory to the engineers. This type is a survival of the days when the chief engineer or competent assistants could give much time to details. I doubt if such specifications proved satisfactory even then. At any rate, in the present days they would be hazardous for both state and contractor. No man can satisfactorily handle all details in supervising the large amount of work being done at present, and much supervision has to be left to subordinates. It is a careless and unnecessary procedure to place the responsibility of deciding broad questions on men of limited experience. Furthermore, a reader of such specifications is impressed with the idea that the state presenting them was in ignorance of just what they did want.

The main factors effecting the relationship between contractor and the state therefore might be enumerated as: first, the type of specification under which the work is done, next the interpretation of these specifications, and finally their enforcement.

I have briefly discussed two general types of specifications to be avoided, and too much emphasis cannot be placed on these points. In order to play fair, the engineers or other officials responsible on the part of the state must see that their specifications are clear in the fact that methods are definitely stated, as far as practical, to do so. If we expect to avoid friction during the progress of work, we must have a proper understanding of what is expected, and this information should be conveyed in the specification. We cannot expect a better class of materials and workmanship than is available. If we call for this latter, the result will be that if the contract is ever completed we will find that we have not met the specification requirement but will probably be faced with the fact that we paid the price for them. A reputable contractor will take the specifications in good faith and assume they will be enforced. If they are impractical, or not properly enforced, the state is the loser, as a successful contractor prepares for the worst condition and bids accordingly.

Interpretation of Specifications.—Now all specifications must be interpreted in many points, and as it is within their authority, this is entirely controlled by the state representatives. The type of a man invested with this authority is a large factor in determining relationship with the contractor, and also has a great influence on future prices. A broadminded man of experience insists upon an excellent quality of work, but he is reasonable enough not to insist on this being obtained the most expensive way.

A certain amount of responsibility and some authority has to be given to the inspector on the contract. The experience of this man and his general type has a great influence on the work and the relationship maintained. This is the state employe, that is most intimately associated with the contractor; and his decisions, although in many cases of a minor nature, are bound to have their effect on the subject under discussion. It is true, with a good specification, his individual opinions are reduced to the minimum, but we must realize that there are still many points on which he has very little to guide him except past experience and good practice.

An inspector first is to inspect and insist on quality and compliance with specification. Any failure on his part in this regard is an absolute neglect of duty. It can be said in praise of the engineer or inspector from a moral standpoint, that a very small proportion deliberately err on the side of neglect of duty, so far as their understanding of the specifications are concerned. In fact, their main faults are improper interpretation of the specifications, insufficient detail, knowledge of the different phases of the work, thereby making them uncertain in making decisions. Inexperience, thereby, unfitting them to determine between a major or minor cause for complaint, and finally a lack of co-operation with the contractor. This latter with inexperience is probably one of the main causes of delays on many contracts. By co-operation, I mean that the inspector should always see that the contract is performed in accordance with specifications, but instead of constantly complaining, he should suggest methods for rectifying poor conditions. His aim should be to secure results and co-operate with the contractor in getting them. For example, in working local materials, the inspector is, or should be informed on what is required, and having facilities for determining this, he can guide the contractor in working deposits so as to insure acceptable material being delivered at the site of the work. Here, I wish to emphasize that there is no intention to interfere with the contractor's methods of working. The inspector should co-operate to the extent that no large amount of material will have to be rejected after hauling to the roadside. You can readily see how much co-operation on the part of the inspector while at the same time maintaining quality, will reduce costs to the contractor which in the end results in lower bids.

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*Abstract of a paper presented Dec. 9 at the convention of the American Association of State Highway Officials.

Another factor is that the state also maintains a reputation for fairness, thereby attracting the better and more reputable contractors. An inspector should avoid indecision, a firm positive attitude on his part will command respect and maintain friendly relations to a greater extent than will the apparent indecision encountered on many contracts. The complaint from contractors on indecision of the engineer or inspector far outnumbers those on positive directions, even though the latter is somewhat severe.

Highway Departments Should Furnish Reliable Information When Calling for Bids.—This gives some definite knowledge to the contractor and allows him to bid with intelligence and thereby reduce his so-called contingency or safety item. Under this head might be mentioned sources of approved materials for construction. It is expected that a contractor will inspect the highway before bidding, but having no facilities for determining quality, he must figure on sources of known quality, regardless of economy. All available material sources should be investigated by the state and full information furnished with the proposal or bidding sheet. This investigation of materials should be made as complete as possible. So far as I know, no attempt has ever been made to guarantee these sources in quality and quantity. It is a question for thought whether it may not pay in the end to do so, but regardless of this I know from past experience that the furnishing of full information on material sources without guarantee has proven economical. These sources, although not guaranteed, must be reliable, and great care and pains taken in their investigations or otherwise very little benefit will result.

Highway officials desire to be fair and hope to impress this sense of their fairness on the contractor, not only to attract bidders but from the general idea of fairness itself. In order to do this, we must impress the contractor with the fact that in giving due consideration to the legal side of a contract, we also know and consider the moral side.

North Carolina Spending $10,000,000 for Road Building.—Proposed road improvements in North Carolina that have been accepted by the State Highway Commission as projects carry a total of 1,135 miles and call for an aggregate expenditure of more than $10,000,000, according to the report prepared by D. H. Winslow, Project Engineer of the Commission for submission to Commissioner Frank Page in summarizing the work of the Commission since its reorganization. Altogether 108 applications have been received from 78 counties in the state, making the average length of each project about 10 miles. Of the total number submitted to the Commission, two have been completed and the account closed, nine have been approximately completed but not closed up, and 27 others are under construction, and seven advertised for early contract. The aggregate expenditures of the commission on 40 of the first 50 projects accepted so far has been $963,380, according to the figures in the project engineer's report. Preliminaries on the remaining projects that have not been completed are being prosecuted by a corps of 35 engineering and surveying parties at work in various sections of the state, and it is believed by the Commission that all of the 108 projects will be ready for submission to the Federal Commission for final approval within the next two months.

Engineering and Related Organizations Have Membership of 263,000.—In the December Proceedings of the American society of Civil Engineers, Mr. Frederick C. Noble estimates that there are at least 247 engineering and related organizations in the United States with a total membership of 263,000. Of these, many are commercial or trade organizations, some are architectural, highway, or gas associations, and a few are scientific societies. Deducting these and taking only those appearing to be composed largely of engineers in one or another well-recognized branch, gives the following result:

No.	Kind.	Members.
1	American Society Civil Engineers	9,030
3	Other founder societies	28,002
27	Other national societies	31,913
12	Regional societies	8,073
24	State societies	10.226
50	Local societies	20.567
117		107,811

Class Specifications for Civil Engineers in Government Service

A committee of engineers appointed by the Reclassification Commission, which is working on a program for salary readjustments for the engineers in the employ of the Federal Government, has prepared class specifications for engineering services. The specifications, which are reprinted below, are for the civil engineering service. The electrical, mechanical and mining engineering services and the specialties in these larger classes, as for instance the highway engineers, the drainage engineers, etc., are covered by the simple process of inserting the appropriate designation in the place of the word "Civil" as it appears in these specifications. Thus where these specifications read, "Senior Civil Engineers," for the highway group they would read, "Senior Highway Engineers" and the duties would be modified by making similar changes and in some cases by the introduction of notations as to special duties performed by the members of this minor group.

The Advisory Committee of the Commission has recommended the following salary schedule which applies to all branches of the profession:

Senior Grade	$8,400-12,000
Professional Grade	5,820- 7,920
Associate Grade	4,260- 5,460
Assistant Grade	2,880- 4,080
Junior Grade	1,860- 2,580
Senior Aid Grade	1,860- 2,700
Junior Aid Grade	1,320- 1,680

The class specifications follow:

Junior Engineering Aids.—Duties: To do miscellaneous subordinate work in the office or field in an organization engaged in any branch of engineering.

Examples: Rodmen; chainmen; recorder; tracer; making simple engineering computations; compiling field data and laboratory notes; filing and indexing maps, plans and notebooks; making blue prints; preparing samples; caring for instruments in field or laboratory.

Qualifications: Training equivalent to common school education.

Suggested Lines of Promotion: To: Civil Engineering Aid.

Civil Engineering Aids.—Duties: To perform, under immediate supervision, minor technical work in connection with the location, preparation of plans or construction of engineering structures.

Example: Making measurements and estimates in the field; acting as recorder or computer in field or office; operating and caring for surveying instruments; compiling data for reports or records; plotting notes and maps; preparing working drawings where design is furnished.

Qualifications: Training equivalent to that represented by graduation from high school, and at least 2 years' experience in engineering work; familiarity with the use of the slide rule; ability to do lettering and drafting and simple computations.

Suggested Lines of Promotion: From: Junior Engineering Aid. To: Junior Engineer in any Civil Engineering Service.

Junior Civil Engineers.—Duties: Under immediate supervision, to perform drafting, computing, surveying, inspecting, and related work in either field or office in connection with investigations, designs, construction, operation and selection of personnel related to the various civil engineering services.

Examples: Surveying with transit or levels using measuring devices for steam gaging; plotting and computing field notes; inspecting various types of structures both during construction and after completion; giving lines and grades for construction; testing apparatus, materials and processes.

Qualifications: Training equivalent to that represented by graduation, with degree, from an institution of recognized standing, with major work in civil engineering. (For valuation work in the Interstate Commerce Commission, the experience must have been in railroad work.)

Suggested Lines of Promotion: From: Civil Engineering Aid. To: Assistant Civil Engineer in all Civil Engineering Services.

Assistant Civil Engineers.—Duties: Under specific administrative and technical direction, to be responsible for the conduct of the work of a minor subdivision of a civil engineering organization; to collect and compile data for specific items of engineering studies; to take immediate charge of field survey projects of, or the design, inspection or construction of minor engineering work; to lay out and develop work from specifications and to supervise the work of a drafting or computing force; or to conduct specific tests or investigations of apparatus, material or processes; and to perform related work as required.

Examples: Directing field parties on construction, or surveys; superintending and inspecting construction work; performing duties of an office engineer; assisting the superintendent of an important engineering structure; preparing technical material for publication; compiling statistical data; preparing questions and rating examination papers used in establishing eligibility of candidates for engineering positions.

Qualifications: Training equivalent to that represented by graduation, with a degree, from an institution of recognized standing, with major work in civil engineering; not less than two years' experience in civil engineering work in field or office; proven technical knowledge and proficiency. (For valuation work in the Interstate Commerce Commission, the experience must have been in railroad work.)

Suggested Lines of Promotion: From: Junior Civil Engineer. To: Associate Civil Engineer.

Associate Civil Engineers.—Duties: Under general administrative and technical direction, to be in responsible charge of an intermediate subdivision of a civil engineering organization; to exercise independent engineering judgment and assume responsibilities in studies and computations necessary for the preparation of reports, estimates, or designs and to have immediate charge of the construction, maintenance or operation of important civil engineering works or projects, or to conduct or direct important lines of civil engineering research.

Examples: Having immediate charge of the construction of water mains, sewers, etc.; testing engineering materials; making cost studies; supervising surveys of areas and acquisitioning of lands; laying out of railroad terminals, yards, storage bases, etc.; estimating and expediting construction work and design.

Qualifications: Training equivalent to that represented by graduation, with a degree, from an institution of recognized standing, with major work in civil engineering; not less than five years of general engineering experience of which at least one year shall have been in the direction or performance of important engineering work; supervisory and administrative experience or a high degree of technical skill. (For valuation work in the Interstate Commerce Commission, the experience must have been in railroad work.)

Suggested Lines of Promotion: From: Assistant Civil Engineer. To: Civil Engineer.

Civil Engineers—Duties: Under general direction, to have responsible charge of, and to initiate and determine policies for, a major subdivision of a civil engineering organization; to prepare for final executive action, reports, estimates, designs, specifications, and data; to have charge of the construction, inspection, maintenance or operation of civil engineering work of major importance; to conduct or direct major lines of civil engineering research; or to furnish for executive action, expert or critical advice on civil engineering works, projects, or policies; or to act as special adviser on civil engineering problems.

Qualifications: Training equivalent to that represented by graduation with degree from an institution of recognized standing, with major work in civil engineering; not less than eight years of general engineering experience, of which at least four years shall have been in the direction or performance of important civil engineering work; large capacity, initiative, and demonstrated ability. (For valuation work in the Interstate Commerce Commission, the experience must have been in railroad work.)

Suggested Lines of Promotion: From: Associate Civil Engineer. To: Senior Civil Engineer.

Senior Civil Engineers—Duties: To perform one or more of the following: (1) To have chief administrative charge of a civil engineering organization and of main divisions thereof, and to determine or execute general policies under the limitations imposed by law, regulation or other fixed requirements; (3) to be responsible for reports, estimates, designs, specifications, etc., or for the construction, maintenance and operation of large civil engineering projects; (3) to have full charge of the collection and presentation of data for, and the conduct of valuation proceedings; (4) to direct, or perform the most comprehensive lines of engineering research; or (5) to act as consulting specialist on important civil engineering projects, policies or valuations.

Qualifications: Training equivalent to that represented by graduation, with a degree, from an institution of recognized standing, with major work in civil engineering; not less than twelve years of general engineering experience, of which at least eight years shall have been in the direction or performance of important civil engineering work of a character to give substantial evidence of engineering knowledge and ability or of executive capacities of the highest order. (For valuation work in the Inter state Commerce Commission, the experience must have been in railroad work.)

Suggested Lines of Promotion: From: Civil Engineer.

A 6-Form System for Keeping Track of Truck Work

A simple system for keeping records of motor truck operations has been perfected by Jacob Fradus, a large contractor of New York City, who operates 9 Mack 7-ton tractors and 25 7½-ton Mack dump trucks. The plan is described in The Commercial Vehicle, from which the following is taken:

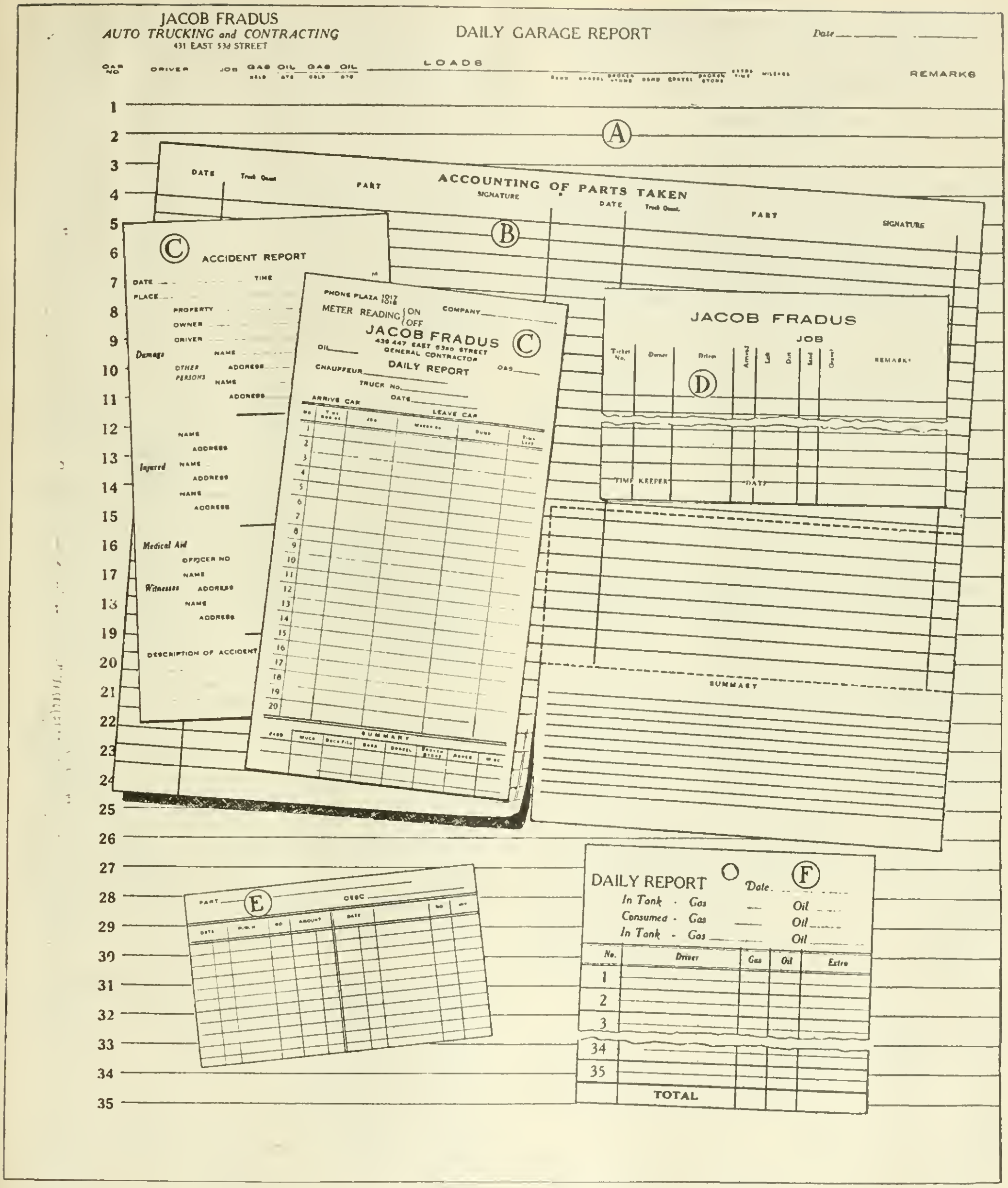
One of the peculiarities in the contractors field is the fact that occasionally the trucks will be working on several contracts at one time. This results in the splitting up of the fleet and lessens the opportunity for one-man supervision. Fradus has solved this problem of supervision by the employment of a timekeeper at each working place. A special form is filled out by the timekeeper each day, giving a record of the number of trips, loads, and the materials hauled by each truck, as well as the time consumed on each trip. This form is marked D in the illustration. On every trip each driver is given a ticket, signed by the timekeeper. These tickets, which are handed in nightly to the foreman at the garage, help in verifying the number of trips recorded on the driver's report.

The timekeper's report also gives a record of the work done by outside trucks, which have been rented to help out on the contract. The column headed by the word Owner is for the insertion of the number of any one of Fradus' trucks or the name of the concern helping out on the contract.

The driver's daily report, shown as C, goes hand-in-hand with that of the timekeeper because it records the same information. In this way, any inaccuracies can be checked up. In addition to this information, the driver must also report the amount of gasoline and oil received and the contracts on which he is working. A record of his time while out on the road is also kept. The dump he goes to is written out on the report, as well as the time he leaves that place and the time he arrives back at the excavation. This information gives an excellent opportunity for time study on any contract to ascertain the number of days, months, etc., **in which** a particular piece of work can be finished.

Provision has also been made on the other side of the driver's report for recording full particulars of an accident When a truck has been in a smashup or has injured someone, the date and place of the accident, together with the time of the day, are written down. If another vehicle has been damaged, the name of the vehicle, together with that of the owner and driver, is recorded on the report. The names and addresses of other persons in the vehicle are also taken. When a person has been injured, his name and address is obtained. The report also records the names and addresses of witnesses, the hospital or place where medical aid was given the injured; the officer's name and station and a description of the accident.

A form, statement A, serving as a final entry for the day's work done by each truck, is kept by the bookkeeper, who takes the driver's reports and those of the time-keepers and copies them in what is called a Daily Garage Report. There is a special column across this report for each truck, giving the driver's name; the job on which he worked; gasoline and oil consumption; the numberr of trips made; the material hauled; extra time spent on the work; the mileage for the day, and any additional information that the driver may want to report. It will be noticed that there are two separate columns for gasoline and also for oil. One pair of these columns is for a record of what has been taken from the garage and the other for any gasoline and oil that has been bought by the driver outside of the garage. Occasionally a truck will work at two or more places during the day. In order to keep an accurate account of the number of trips made at each place, six columns under the heading, Loads.



JACOB FRADUS
AUTO TRUCKING and CONTRACTING
431 EAST 53d STREET

DAILY GARAGE REPORT

Date

CAR NO. DRIVER JOB GAS OIL GAS OIL LOADS REMARKS

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35

ACCOUNTING OF PARTS TAKEN

DATE Truck Quant. PART SIGNATURE DATE Truck Quant. PART SIGNATURE

ACCIDENT REPORT

DATE TIME
PLACE
Damage PROPERTY OWNER DRIVER NAME OTHER PERSONS ADDRESS NAME ADDRESS
Injured NAME ADDRESS NAME ADDRESS NAME ADDRESS
Medical Aid OFFICER NO
Witnesses NAME ADDRESS NAME ADDRESS
DESCRIPTION OF ACCIDENT

PHONE PLAZA 1817 1818
METER READING {ON OFF
COMPANY
JACOB FRADUS
439 447 EAST 63RD STREET
GENERAL CONTRACTOR
OIL
DAILY REPORT
GAS
CHAUFFEUR
TRUCK NO.
DATE
ARRIVE CAR LEAVE CAR
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
SUMMARY

JACOB FRADUS
JOB
Ticket No. Owner Driver Arrived Left REMARKS
TIME KEEPER DATE

SUMMARY

PART DESC
DATE AMOUNT DATE

DAILY REPORT Date
In Tank - Gas Oil
Consumed - Gas Oil
In Tank - Gas Oil

No.	Driver	Gas	Oil	Extra
1				
2				
3				
34				
35				
	TOTAL			

Forms for Keeping Track of Truck Work and Spare Parts.

have been inserted in the report, generally sufficient for one for each piece of work under way.

A necessary adjunct to the fleet owner's garage is the stockroom. Here are kept spare parts, repair material, etc. And here occur the most serious leaks in the operation of the garage. The mechanic comes to the supply room for parts and material. Sometimes he is in urgent need of a part, and takes it without waiting to notify the stock clerk. The driver in need of gasoline secures 5 gal. and leaves a scribbled memorandum which blows away and is lost. At the close of business, the inventory fails to check. Fradus has stopped these leaks in the stockroom by making each employe sign for every part or gallon of gasoline taken, not on a slip of paper, but on a more permanent record kept by the stockroom clerk. He is supplied with a monthly report sheet for keeping a record of the parts taken out of the stockroom.

In the lower right corner of this report, space is set aside for a summary of all the parts taken out of the stockroom. Fradus has adopted a novel scheme in regard to this summary in which fleet owners will be interested. Instead of allowing the space set aside for the summary to be exposed to the dirt and grime usually found on reports that have been handled by the shop men, this space is folded under the sheet during the month. When the summary is made, the stockroom clerk has a clean sheet to work on and the bookkeeper is greatly facilitated in his cost keeping.

Cost Plus Contract Involving Profit Sharing Between Owner, Contractor and Employees

By J. A. L. WADDELL,

Consulting Engineer, Kansas City and New York.

None of the modified methods of the "cost-plus" system, involving some means or other of profit-sharing, which have yet been tried in practice, can be said to be entirely satisfactory to the owner, though possibly so to the contractor, in that they all fail to put a limit on the total cost of the construction or to penalize a contractor who, through either wilfulness or carelessness, allows the cost of construction to pass the bounds of reason. It does not suffice to stipulate in the contract that, when the total cost passes a certain amount, the allowance for profit is gradually to be reduced until a certain minimum limit, however small it may be, is reached. The setting of that limit leaves the contractor in a position to take life easily and to avoid personal worry after his hard luck has attained to a certain magnitude; for, subsequently to that, he will lose nothing but his time and the possible use of his plant on some remunerative contract, while the owner will have to pay whatever additional amount the job may cost.

Salient Features of an Ideal System of Contract-Letting and Profit-Sharing.—The essential requirements of an ideal type of contract are as follows:

First—It must provide a means of sharing with the workmen on an equitable basis the total net profit on the job.

Second—It must set some kind of a limit to the total cost of the work, so as to prevent a careless or conscienceless contractor from running up the expense to an outrageously great amount.

Third—It must reduce to a minimum the chance of the contractor's being out of pocket on the completion of the work, unless such condition is due to his own carelessness or lack of push.

Fourth—It must retain all the advantages of competitive bidding, so as to give every capable and worthy contractor who is desirous of figuring on the work an even chance of securing the contract.

Fifth—It must provide an incentive for the contractor and all his assistants and workmen to use every legitimate effort to make the work as inexpensive as possible, without violating in any manner the requirements of the specifications.

Sixth—It must provide a just and equitable basis of payment for a possible increase in the estimate of total quantities and for adjusting satisfactorily to all concerned the reduction of payment due to a possible diminution thereof.

Seventh—It must ensure that the owner will be acting for his own best interests by aiding the contractor in every possible way to complete his work quickly and inexpensively, provided, of course, that it is done in such a manner as to guarantee the attainment of the owner's ultimate purpose, as expressed in the specifications.

Eighth—Its provisions must be such as to keep constantly in good humor every one connected with the construction.

Ninth—Its method of final settlement of accounts must be clear, simple, and easy of application; and the keeping of them during the progress of the work must be no more complicated or expensive than it would be in the case of any ordinary "cost-plus" contract.

Description of the Ideal Method—Let the specifications, which should invariably be drafted by an engineer who is acknowledged to be an expert in the class of work covered in the proposed contract, be complete and thorough in every detail, recording all that is known concerning the governing conditions; pointing out all features about which there is any uncertainty; tabulating as accurately as possible the estimated quantities of all the materials that will probably enter the construction; providing a justly drawn clause for unclassified work and the payment therefor; calling for each bidder to submit in full detail his estimate of actual cost of doing the work by applying to all quantities of materials given in the specifications, unit-cost prices (termed Schedule A), each price containing a proportionate share of any contingency allowance that may have been made, totaling the products so as to form "Sum A," and adding thereto the amount of profit which he has decided to ask, thus making "Sum B." This last amount will, in reality, represent the bidder's tender; but to it, if it is accepted, there will be added a profit for the owner, exactly equal to that asked for by the successful bidder, and another profit or bonus for the employes, amounting to a previously fixed percentage say, 20 or 25) of the sum of the aforesaid profits of the contractor and the owner, thus making "Sum C." This last sum is the temporary limit of total expenditure on the part of the owner, based on the assumption that the approximate quantities of materials given in the specifications are correct. The ratio r of "Sum C" to "Sum A" is to be applied to each of the unit prices used in the preparation of the cost estimate, in order to obtain the list of unit prices (termed "Schedule B") to apply temporarily to the actual quantities of materials in the completed construction, when making the final adjustment of accounts.

If there are any items of expense of construction not covered by the list given in the specifications, the clause of the latter relating to "Unclassified Work" will take care of them. That clause should stipulate that, for all such unlisted items, the actual cost of labor and materials therefor, without any allowance for superintendence or overhead, is to be recorded; and to it is to be added later 30 per cent of its amount to allow for superintendence, overhead, and the various profits This sum is to be added to the total value of the actual quantities of all the materials listed in the specifications figured at the proportionately increased unit prices as given in "Schedule B"; and the result, "Sum D" (with a single modification explained hereinafter), will be the final limiting cost to the owner and the basis for computing the net profits to be divided between the contractor, the owner, and the workmen.

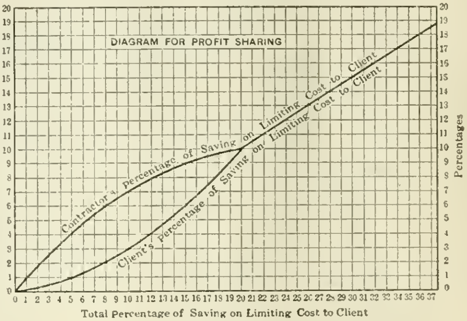


Fig. 1—Chart for Profit Division.

The specifications, of course, will contain a clause providing a surety company bond for the faithful performance of the work and for guaranteeing the client against having to pay more than the limiting sum agreed on (as finally modified).

Method of Profit-Sharing Contract—The following method of profit-sharing between the contractor, the owner, and the employes is to be adopted:

An accurate estimate of cost of every detail of the work from start to finish is to be kept by the contractor and verified by an accountant in the employ of the client, so that the total profit on the job may be ascertained by deducting this total cost from the maximum figure named in the contractor's tender and afterward embodied in the contract (modified, however, as hereinafter described). This profit, less the amount of the employes' bonus, is to be shared between the contractor and the client as indicated in the profit diagram. Fig. 1. It should be clearly understood that every direct and indirect expense to which the contractor is put in doing the work, after the contract is signed, is to be included in the cost—all overhead expenses of every kind, plant deterioration, traveling expenses, supervision, and salaries, excepting only that the contractor himself is not entitled to any salary. In the case of a firm being the contractor, the head of that firm should receive no salary; but if any of the juniors devote their time exclusively to the job, it would be legitimate to allow them reasonable salaries, equivalent to what would

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From the October-November-December, 1919, proceedings of the American Society of Civil Engineers.

have to be paid to regular assistants. All such matters, however, should be stipulated in the contract.

In order to determine, after the entire job is finished, the amount due the contractor, "Sum C" is to be subtracted from "Sum D," and the ratio which this difference (either a positive or a negative quantity) bears to "Sum C" is to be figured and adopted in the use of the diagram of "corrective ratios" (Fig. 2) for the said difference.

Application of Corrective Ratio—There are two reasons for applying this corrective ratio:

First—In the case where the actual quantities of materials exceed the estimated ones of the specifications, it would be hardly fair to the owner to apply to the excess those unit prices which produce his tentative limiting expenditure.

Second—In the case where the actual quantities of materials are less than the estimated ones, it would be unjust to the contractor to use the high unit prices on the diminution quantities, not only because of the great difference between these and the unit actual costs, but also, for the reason that the total overhead charges would be about the same for the diminished accounts as for the estimated total quantities.

In the corrective ratio diagram (Fig. 2), it will be noticed, that, after the ratio of value difference (due to increase or diminution of quantities of materials) reaches 0.2, the "corrective ratio" remains constant at 0.8, which corresponds approximately to actual cost conditions. The object of this is to provide that the contractor shall not be too much benefited by an abnormal increase in quantities, nor, on the other hand, shall he obtain too much advantage because of an abnormal diminution thereof.

To utilize the corrective ratio diagram (Fig. 2), look on the line of abscissas for the ratio of cost difference, pass vertically upward to the curve (or right line, as the case may be), then horizontally to the extreme left vertical, which will indicate the corrective ratio required. Next, multiply the previously computed difference by this corrective ratio, and add the result to or subtract it from "Sum C." The result, "Sum E," will be the finally corrected limit, from which must be subtracted the total actual cost so as to determine the amount of profit to be divided. The first step in such division is to set aside the employes' share on the basis of percentage agreed on; and the next is to divide the remaining profit between the contractor and the owner, as per the profit diagram (Fig. 1).

The size of the percentage of the declared profit to allow the employes will depend on the character of the work covered in the contract in respect to the proportionate division of the cost between materials and labor. Under ordinary conditions, the division is about half and half, in which case the employes' percentage should be from 20 to 25; but where the labor cost preponderates these figures should be increased, and where the materials cost is the greater they should be diminished.

Division of Bonus Among Employes.—In respect to the division of this bonus among the employes, the following method is suggested:

Only those workmen or assistants of any class who have stayed on the job, either until its completion or until their services were no longer needed, should participate in the profits; and the amount of the share of each such workman and assistant should be in the proportion which his total earnings on the work bears to the grand total of the earnings of all those employes who so participate. As, in any good business organization, a record is always kept of the amount of salary or wages paid to each employe on any contract, it would require only a few hours of extra work for the bookkeeper, after the job is finished, to compute each man's proportionate share of the bonus.

There is an additional protection against possible loss which might be given to the contractor under certain conditions, especially on work to be done in a foreign country. If it be anticipated that during construction any large general rise in the price of labor is likely to occur, thus greatly augmenting the total cost of the work, the limiting total expenditure of the owner, as hereinbefore finally adjusted, should be increased by an amount figured thus:

Determine the average current wages for common labor at the time of letting the contract, and the average paid therefor during the entire time occupied by the construction, and call the ratio of these two averages r′; then figure the total amount of salaries and wages paid to employes from start to finish and call it W. Then,

$$W\,(r' - 1) \times 1.2$$

will be the amount required, the factor, 1.2, covering a fair allowance for overhead and profits.

It has been suggested of late in the technical press that the contractor himself should be paid a salary by the owner, in addition to whatever profit he may make on the job. Such a policy would be simply suicidal on the part of the owner, for if the work were to be handled badly, the contractor might continue to earn money while the owner would be losing heavily. The writer has met with just such a case; hence, in this particular, he certainly knows whereof he speaks. Such a practice should never, under any conditions, be countenanced by either the owner or his engineer.

Example of Profit Sharing Method.—In order to illustrate the modus operandi of this method of profit-sharing, let us assume the following case, in which the estimated quantities are exceeded. For the purpose of simplification in figuring, round numbers have been assumed for both the quantities of materials and the unit costs thereof. The job is one of railroad construction, and the number of items is intentionally limited for the sake of convenience.

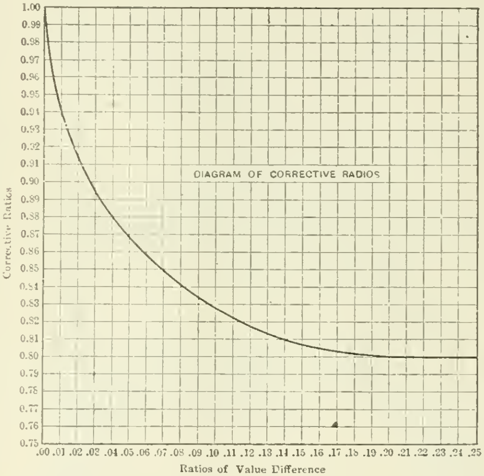

Fig. 2—Corrective Ratios.

The following are the quantities of materials supposed to be stated in the specifications:

Earthwork, measured in cutting	1,000,000 cu. yd.
Loose rock, measured in cutting	100,000 cu. yd.
Solid rock, measured in cutting	40,000 cu. yd.
Concrete in structures	10,000 cu. yd.
Wooden trestle	2,000 lin. ft.
Structural steel work, erected	500,000 lb.

The tender of the successful bidder was as follows:

	Quantities.	Schedule A.	Totals.
Earthwork	1,000,000 cu. yd.	@ $0.50 =	$ 500,000
Loose rock	100,000 cu. yd.	@ $1.00 =	100,000
Solid rock	40,000 cu. yd.	@ $1.50 =	60,000
Concrete	10,000 cu. yd.	@ $20.00 =	200,000
Wooden trestle	2,000 lin. ft.	@ $50.00 =	100,000
Steel work	500,000 lb.	@ $0.08 =	40,000
Total estimated cost ("Sum A") =			$1,000,000
Profit required, 10% =			100,000
Tender ("Sum B") =			$1,100,000
Allowance for owner's profit =			100,000
Employes' profit, 25% of $200,000 =			50,000
Temporary limit ("Sum C") =			$1,250,000

$$\text{Ratio, } r = \frac{\text{Sum C}}{\text{Sum A}} = \frac{\$1,250,000}{\$1,000,000} = 1.25.$$

The proportionately increased unit prices, therefore, will be as follows:

Earthwork	$0.50 × 1.25 = $0.625
Loose rock	$1.00 × 1.25 = $1.25
Solid rock	$1.50 × 1.25 = $1.875
Concrete	$20.00 × 1.25 = $25.00
Wooden trestle	$50.00 × 1.25 = $62.50
Steel work	$0.08 × 1.25 = $0.10

The actual quantities of the materials in the completed job were, as follows:

Earthwork	980,000 cu. yd.
Loose rock	110,000 cu. yd.
Solid rock	50,000 cu. yd.

Concrete	10,500 cu. yd.
Wooden trestle	2,100 lin. ft.
Steel work	480,000 lb.

In addition, there was done by the contractor certain "unclassified work" which actually cost him for labor and materials $20,000.

The revised estimate is, therefore, as follows:

Earthwork	980,00 cu. yd.	@ $0.625	=	$ 612,500
Loose rock	110,000 cu. yd.	@ $1.25	=	137,500
Solid rock	50,000 cu. yd.	@ $1.875	=	93,750
Concrete	10,500 cu. yd.	@ $25.00	=	262,500
Wooden trestle	2,100 lin. ft.	@ $62.50	=	131,250
Steel work	480,000 lb.	@ $0.10	=	48,000
Unclassified work	$20,000 × 1.3		=	26,000
Summation, or "Sum D"			=	$1,311,500

The difference between "Sum D" and "Sum C" equals

$1,311,500 — $1,250,000 = $61,500.

$$\text{Ratio of difference} = \frac{\$61,500}{\$1,250,000} = 0.0492;\ \text{say, } 0.05.$$

For this ratio, the diagram, Fig. 2, gives a corrective ratio of 0.865, which multiplied by $61,500 gives $53,198, say, $53,200, making the corrected limit, or "Sum E," = $1,250,000 + $53,200 = $1,303,200.

If the total actual cost of the work, including that of the unclassified work without allowance for superintendence or overhead, amount to $1,100,000, the total profit would be:

$1,303,200 — $1,100,000 = $203,200.

Of this, the joint share of the contractor and the owner would be:

$203,200 ÷ 1.25 = $162,560;

and the employes' bonus would be:

$203,200 — $162,560 = $40,640,

which is exactly 25 per cent of $162,560.

In this respect to the division of this last amount between the contractor and the owner, its ratio to total cost is:

$162,560 ÷ $1,100,000 = 0.148, or 14.8 per cent.

From the diagram for profit division (Fig. 1), we find the division of this percentage to be:

	Per cent
Contractor	8.9
Owner	5.9

This makes the total payment by the owner to the contractor:

$1,100,000 × 108.9 = $1,197,900.

Let us now take a case where there is a diminution in the estimated quantities of materials. Using the same case as before in respect to estimated quantities and tender, we shall assume the following actual quantities of materials:

Earthwork	1,050,000 cu. yd.
Loose rock	50,000 cu. yd.
Solid rock	20,000 cu. yd.
Concrete	8,000 cu. yd.
Wooden trestle	1,800 lin. ft.
Steel work	450,000 lb.

The cost of the unclassified work was $20,000, as in the preceding case.

The revised estimate is, therefore, as follows:

Earthwork	1,050,000 cu. yd.	@ $0.625	=	$ 656,250
Loose rock	50,000 cu. yd.	@ $1.25	=	62,500
Solid rock	20,000 cu. yd.	@ $1.875	=	37,500
Concrete	8,000 cu. yd.	@ $25.00	=	200,000
Wooden trestle	1,800 lin. ft.	@ $62.50	=	112,500
Steel work	450,000 lb.	@ $0.10	=	45,000
Unclassified work	$20,000 × 1.3		=	26,000
Summation, or "Sum D"			=	$1.139,750

The difference between "Sum D" and "Sum C" equals

$1,139,750 — $1,250,000 = — $110,250

$$\text{Ratio of difference} = \frac{\$110,250}{\$1,250,000} = 0.0882$$

For this ratio, the diagram gives a corrective ratio of 0.835, which, multiplied by $110,250, gives $92,059, say, $92,100, making the corrected limit

"Sum E" = $1,250,000 — $92,100 = $1,157,900.

If the total actual cost of the construction, including that of the unclassified work without allowance for superintendence or overhead amounted to $880,000, the total profit would be:

$1,157,900 — $880,000 = $277,900.

Of this, the joint share of the contractor and the owner would be:

$277,900 ÷ 1.25 = $222,320.

and the employes' bonus would be:

$277,900 — $222,320 = $55,580,

which is exactly 25 per cent of $222,320.

In respect to the division of this last amount between the contractor and the owner, its ratio to total cost is:

$222,320 ÷ $880,000 = 0.253, or 25.3 per cent.

From the diagram for profit division, (Fig. 1), we find the division of this percentage to be on the "fifty-fifty" basis, making the total payment by the owner to the contractor = $880,000 × 1.1265 = $991,320.

Advantages—The advantages of this method of contract-letting are as follows:

First—While it is true that the client at the outset does not know exactly what the work is going to cost him, he is positive that it will not cost him materially more than a certain amount, provided his engineer's estimate of quantities is about right, as, generally speaking, it certainly ought to be.

Second—The client has the satisfaction of feeling that even if, in his opinion, the limit determined by the contractor's bid is excessive, and that the final net profit on the job, in consequence, will be too large, the said net profit will be shared between them on a "fifty-fifty" basis.

Third—While the client is bound to pay a certain percentage of the joint profit as a bonus to the contract's employes, generally he will not be out of pocket thereby, but, on the contrary, he will gain; because the incentive that the prospective bonus gives to all hands to labor energetically will save in the total cost much more than the amount of the bonus.

Fourth—All the advantages of competitive bidding are retained by this method, because the fully capable competitor who tenders the lowest amount for "Sum B" should be awarded the contract. All bids will be on exactly the same basis, no modification of the stipulated method of tendering being permitted. It is understood, of course, that the contract will not be awarded to any competitor who does not possess the necessary experience, capital, and plant, and who has not an established reputation for doing good and satisfactory work.

Fifth—The contractor, if he was not too keen in bidding, knows that there is almost no chance whatsoever of his losing money on the job; because before doing so he would have to use up his allowance for contingencies, his own estimated profit, a profit of like amount allowed for the owner, and a substantial sum representing the employes' bonus. If he ever does use up all these safeguards, the chances are many to one that the fault therefor is entirely his own, being due to his negligence, lack of forethought, or deficiency in energy and push; and in that event he certainly would deserve to be penalized.

Sixth—All the workmen and salaried employes of the contractor will be satisfied with their job because of the excellent opportunity offered for extra compensation; and they will, of their own accord, work diligently, and occasionally even overtime, in order to expedite the construction. Of their own accord, too, they will run off the job any employe who is a chronic shirker, and they will make it their business to keep everybody busy; because the more cheaply the construction is done the greater will be the bonus to divide among the faithful employes who stick by the work to the finish.

Seventh—The method of profit-sharing given by the diagram for profit division (Fig. 1), is eminently equitable, in that when the net amount is small, nearly all of it goes to the contractor, and, as it augments, a continually increasing proportion of it goes to the owner, up to the point where the total joint profit amounts to 20 per cent, after which the partition is on a "fifty-fifty" basis.

It will be seen that for a total net joint profit of less than 20 per cent the following divisions will prevail:

With 5% net, 4% goes to the contractor and 1% to the owner.
With 10% net, 7% goes to the contractor and 3% to the owner.
With 15% net, 9% goes to the contractor and 6% to the owner.

The 20 per cent was selected for equal division as being the one above which a contract is generally deemed by contractors to be good, slightly below which it is only fair, and much below which it is bad; for it corresponds to a net profit of 10 per cent. That is as small a margin as is generally deemed safe for any bidder to tender upon, and yet it constitutes a satisfactory profit on a finished job. As for limiting the client's share of the profit to one-half—that is reasonable and just, because he would have no moral right to receive more than his partner, the contractor. If the client's share were allowed to increase indefinitely, it is conceivable that, with a very large prospective total profit, the contractor could save money for himself by making the work more expensive.

Any bidder who tenders on the basis of a profit less than 10 per cent should be looked on askance by the owner and his engineer; and such a competitor should not be awarded the contract, unless he possesses an exceptionally fine reputation for doing good work and for not quitting his job before finishing it. It is true that during very hard times many worthy contractors are willing to work almost for actual cost, in order to keep their workmen employed; and in such cases the good intention should be recognized in making the award. Nevertheless, it nearly always proves to be unsatisfactory to both the owner and his engineer to let a contract for any piece of construction at a figure below its real value.

Eighth—The contractor will feel during the progress of the construction that the client is a partner on the job, and that, therefore, he and his engineers will not be likely to be unnecessarily severe in their requirements, also that they will permit the adoption of all legitimate expense-saving expedients, and will not demand too many frills on the finishing.

Ninth—Owing to the justice and equity involved by this method of contract-letting and profit-sharing, all concerned in the execution of the work will labor whole-heartedly and good-naturedly, avoiding petty squabbles and disagreements; and the result will be earnest, honest effort, a satisfactory piece of construction, and the general contentment of both parties to the agreement.

Tenth—While this method may at first glance have the appearance of being complicated, it is quite simple; and because of the clear manner in which it is explained herein, it is easily utilized in any actual case by following one step at a time the directions given. The nomenclature of "sums" and "schedules" renders the application of the method very easy. Moreover, it must be remembered that it is to be used only once for each contract, and then only after all the work is completed and the accounts are in proper form. Again, the keeping of the accounts is in no way any more complicated than it would be in case any of the "cost-plus" methods were used.

State Highway Construction and Maintenance in Connecticut

The report of the State Highway Commission of Connecticut for the fiscal term ending June 30, last, made public on Jan. 2, contains much interesting information, some of which is abstracted below. The fiscal year was changed by the last legislature so the report covers a period of only 9 months.

Reconstruction with Hard Surface Pavement Reduces Cost of Maintenance.—The report a year ago called attention to the fact that there was a constant increase in the cost of material and labor which it was hoped at that time would stop. These hopes have not been realized. The cost of construction is very much higher and the maintenance cost per unit has materially increased. Nevertheless, due to the policy of reconstructing with hard surface pavements the total cost of maintenance for a full year is no larger than it was for the same previous period.

Expenditures in Fiscal Year.—The total gross expenditures of the department for the nine months from Oct 1, 1918, to June 30, 1919, are $2,385,934. The refunds from all sources for the corresponding term are $436,432, making a total net expenditure for the nine months $1,949,502. This amount cannot be compared with the expenditures for the previous year because only nine months are included. The net income from automobile fees for the corresponding term was $1,361,898.

The expenditures for the actual work of the department are made under three heads: First, construction of highways; second, construction and maintenance of bridges; third, maintenance, repair and reconstruction of existing highways:

The amounts spent during the nine months on all state roads and bridges are as follows:

Construction of all new roads		$ 435,751
Maintenance and construction of bridges		423,549
Maintenance and reconstruction of roads		1,437,190
Divided into reconstruction or replacements	$469,562	
Ordinary repairs and equipment	967,622	

The overhead expenditures which include the cost of the office and engineering for all the department for the nine months was $89,442. This sum does not include the sums paid for repair supervision, but was spent in administering the whole department and in engineering and inspection on work to the total of $1,328,869.

Returned Soldiers Not Anxious to Take Up Road Construction.—Early in the year 1919, the department was urged by Governmental agencies and by other agencies having to do with the welfare of the returned soldier to carry on highway construction, immediately, in order to provide for the home-comers. These seemed reasonable requests, and the department endeavored to comply. It was found that the returning soldier was not anxious to do work of this character and that there was work of other and more lucrative kinds which he could easily secure. Even early this year and during the time covered by the report, there was a shortage of labor which at times approached the acute. When there is a general shortage of man power, the individual takes a step forward and is able generally to secure a higher type of work than he has done before. Consequently, the lowest type of labor performed will be curtailed. The work, being of an inferior character requiring little skill, was among the first to suffer. Nevertheless, the maintenance work of the department was successfully carried on; a considerable amount of construction work was initiated, and at the time of this report is in a fair way to be complete.

A total of 27.81 miles of new road has been built during the term covered by this report which brings the total net mileage of state highway in the state, both state aid and trunk line to 1,510.83 miles. In this connection, while not included in the construction account, the department has reconstructed with hard surface pavement 17.48 miles during the term covered by the report.

Mention has been made in previous reports, particularly in that of 1917-18 of the necessity of constructing hard pavement on the main traveled highways. The development of the motor truck, partly due to the lack of efficiency on the part of the railroads, has made this need more pressing, and the policy of the department in constructing hard surfaced roads will be followed out in the future.

Maintenance and Repair.—This work has been carried on for nine months at a reasonable cost, and an examination of the total year's expenditure for all road repair reveals the fact that the cost for 12 months is approximately the same as that for the corresponding 12 months of the year previous, which is a remarkable achievement and due, probably, to the policy of reconstructing the main trunk line roads with hard surfaced durable pavements of suitable width. The total amount expended for the repair of trunk line roads alone for the past 6 years is as as follows:

1913-14	$ 785,099.34
1914-15	879,936.44
1915-16	981,608.73
1916-17	1,495,486.45
1917-18	1,641,692.97
1918-19 (9 months)	1,064,223.00

The figures given for 1918-19 do not correspond to that given in the previous statement which was for all state roads while this total is for trunk lines only and includes all the expenditures for maintenance of trunk lines, both ordinary and for replacement and reconstruction, plus the cost of oiling both trunk line and state aid roads, but not the cost of supervision and equipment.

The oiling of state aid roads is paid for by the state out of the motor vehicle receipts with no refund from the town.

The following table gives the cost of maintenance, ordinary reconstruction and replacements on trunk line roads only:

	Miles maintained.	Ordinary.	Replacements.	Total.
1913-14	744.57	$587,182	$197,916	$ 785,099
1914-15	906.92	665,761	214,174	879,936
1915-16	915.76	567,130	414,478	981,608
1916-17	923.43	709,419	786,066	1,495,486
1917-18	935.76	904,274	737,418	1,641,692
1918-19 (9 months)	954.62	661,926	402,297	1,064,223

The total does not include the cost of supervision and equipment.

The source of funds for the purposes of maintenance and reconstruction of trunk line roads is an appropriation of $1,000,000 for two years, or $500,000 for one year plus receipts from automobile fees for the term October 1, 1918 to June 30, 1919. The receipts from automobile fees were $1,361,898. The grand total of all expenditures from this account for the nine months or the corresponding term during which these fees were received was $1,238,586.

Maintenance of State Aid Highways.—The following figures show the annual gross expenditures for the past six years for the maintenance of State Aid Highways:

	Miles maintained.	
1913-14	380.84	$119,678
1914-15	481.92	165,741
1915-16	513.24	178,765
1916-17	533.83	191,955
1917-18	545.70	201,179
1918-19 (9 months)	556.23	131,333

The cost of supervision for both State Aid and Trunk Line highways is given for the past five years:

	Supervision.
1914-15	$54,084.91
1915-16	61,856.17
1916-17	57,700.47
1917-18	75,719.72
1918-19 (9 months)	62,367.35

It will be noticed that the expenditure of $62,367 for supervision and office is made in administering and expending the sum of $661,926, ordinary repairs to trunk lines, plus $131,333 ordinary repairs to State Aid Roads, or $793,259. This expense includes all expenditures in connection with supervision and operation.

The following amounts were spent for repair equipment, including motor trucks, crushers, rollers, scrapers and other small tools:

1914-15	$ 24,105
1915-16	55,271
1916-17	65,307
1917-18	193,100
1918-19 (9 months)	111,995

The policy of the department is to charge this equipment against the jobs on which it is used at a price equal to the ordinary rental of similar equipment from outside sources. Refunds are paid back to the repair department on this basis and included in the expenditures for ordinary repairs. Consequently, the net cost of equipment for the nine months, reduced by the rentals charged against the repair fund, is $14,939, that is, the rentals charged against the department by the equipment account are $97,056.

It will be noticed from this statement that the equipment account is practically self-supporting and justified its establishment. There can be no criticism of the rentals charged as they are the same or a trifle less than the prices charged by owners of equipment outside.

Readjustment of Motor Fees.—Mention has been made of the amount of automobile fees for the past year. The total of these fees should, in general, be sufficient to pay for the ordinary repairs of roads, the cost of supervision and the rental of equipment with a possible contribution toward the replacement of roads worn out by the automobiles themselves. There should be a readjustment in the fees so as to charge a heavier amount against the motor truck which does the greater amount of damage. Some basis of comparison should be reached whereby the fee should be based upon the amount of damage to the road. This problem is one which is being worked out carefully by highway engineers, and it is hoped within the next year to be able to report something in this connection which will be reasonable and acceptable to the motor manufacturer and to the public who pay for and use the roads.

A National Program for Highway Research

The urgent need for the immediate inauguration of highway research in accordance with a comprehensive national program was pointed out by Anson Marston, Dean of the Division of Engineering of Iowa State College in a paper presented at the recent meeting of American Association of State Highway Officials. The paper practically in full follows:

The country is about to spend untold billions of dollars in the construction of paved roads. Yet there is a very serious lack of the fundamental scientific data which are absolutely essential to the correct design and construction of paved roads. The stresses in pavement slabs due to traffic, the effect of impact and abrasion, of variations in temperature, of non-uniform foundations, the cost of the various elements of highway transportation and the effect upon each element of each item of road improvement, all these, and many other fundamental things, require very extensive scientific experimentation to develop the true foundation principles of really scientific highway engineering.

Existing Agencies for Highway Research in the United States.—The American Association of State Highway Officials has already taken measures to coordinate highway research by the various state highway departments by establishing a tests and investigations committee, which is already organized and which has been doing some very good work this year.

Undoubtedly every state highway department is a potential agency for important highway research, and no national program for such research can be made successful without the co-operation of the highway departments.

The United States Bureau of Public Roads is undoubtedly spending more money, at the present time, in direct scientific highway experimentation than any other agency. The work in devising instruments for measuring stresses in pavement slabs and in the subgrades, and the actual measurements of the effect of impact, etc., are already of great value.

Many of the road laboratories of engineering colleges and engineering experiment stations are well equipped and can undoubtedly be enlisted in a highway research program.

As illustrating such work already under way, it may be said that the Iowa engineering experiment station is required, by state law, to spend at least $10,000, annually, of its funds for road experimentation, and that it is actively engaged in a research on the determination of all elements of cost of highway transportation and the effect upon each element of cost of highway transportation of each element of road improvement; upon which investigation it proposes to spend at least $7,500 per year for a period of several years.

Municipal testing laboratories are available in a number of large cities which could do valuable work.

Manufacturers' research departments and associations should be able to render valuable assistance.

The great national engineering societies can render effective assistance in organizing a national program, and in determining the use to be made of the scientific data to be secured.

Commercial Laboratories Consulting Highway Engineers.—It must be apparent that there is need for co-ordinating the eight research agencies mentioned above, in order to insure covering the entire field of highway research adequately and without unnecessary duplication of effort.

A Plan for a National Program of Highway Research.—A number of conferences have recently been held by representatives of highway laboratories, of a sectional State Highway Department Association, of the U. S. Bureau of Public Roads, and of the National Research Council, at which a tentative outline plan for a national program of highway research has been evolved.

This tentative plan is to organize six research committees, each to have charge of a definite line of highway research, and each committee to have representatives from all the various agencies to be enlisted, and from all sections of the country.

Each of the eight research agencies in this country, as enumerated above, will of course take active part in organizing the national program of highway research (otherwise it could not be a success) and the co-operation of the engineering division of the National Research Council has been asked.

The National Research Council has been organized by the national government for the general purpose of organizing and co-ordinating scientific research of this character. The engineering division of the Research Council has acted favorably upon the general plan herein outlined.

Six Highway Research Committees Recommended.—The six highway research committees recommended are as follows:

Committee on the Economic Theory of Highway Improvement: Determination of all elements of cost of highway transportation (both motor vehicle and animal drawn), and the effect upon each cost element of each element of highway improvement (improved surface, grade reduction, elimination of rise and fall, etc.,) to enable reliable and scientific determination of the sums which could be economically expended for specific highway improvements.

Committee on Structural Design of Roads: Experimental determination of stresses, strains and behavior, of impact and abrasion, in actual roadways under actual traffic; including also the effect of temperature variations, freezing and thawing, non-uniform subgrades and other factors; in order to establish reliable scientific theory for the structural design of roads.

Committee on Properties of Road Materials: To investigate the properties of road materials and their combinations, including devising and standardizing tests.

Committee on Methods of Road Construction: To collect and disseminate information on the various methods of securing efficient results in road construction, under various conditions and in the different parts of the country.

Committee on Maintenance Methods and Design: To collect and disseminate information on the various maintenance methods and the principles of maintenance design which are found to give best results under different conditions in the various sections of the country.

Committee on Highway Bridge and Culvert Research: Investigation of the waterways required for different classes of culvert and drainage areas. Investigation of the distribution of wheel loads over bridge floors. Other unsolved problems of highway culverts and bridges.

Relation of the American Association of State Highway Officials to a National Program for Highway Research.—The author believes that the executive committee of the tests and investigations committee of the American Association of State Highway Officials should now proceed to co-operate actively in organizing and making a success of some national program of highway research, such as outlined above, or some other practicable program in which all the research agencies can be enlisted. The organization of each committee should be worked out in such a way as to provide adequately for representation from the state highway departments of the country, as determined by the executive or tests and investigations committees. There are very many ways in which the many state highway departments can cooperate in the actual researches. In fact, many of the researches cannot be made successfully without the active co-operation of the state highway departments. There are many data needed which can be collected best by the highway departments. Our executive and tests and investigations committees should have full authority to act for us in co-operating in a national program of highway research.

Street Cleaning Practice at Buffalo, N. Y.

A resumé of the street cleaning practice at Buffalo, N. Y., was given by Mr. George H. Morton, City Engineer, in the committee report submitted at the last annual convention of the American Society for Municipal Improvements. The matter following is abstracted from the report:

In street cleaning, for many years the old horse brooms had been used preceded by an attempt at sprinkling. A few years ago the condition was reached where the equipment of the contractor was obsolete. A renewal of the contract did not seem desirable. Three appraisers were named by the council, with the consent of contractor, to appraise the whole plant, which consisted mainly of horses, mules, broom sweepers, wagons, sleighs, horse equipment and leased barns.

After some adjustments the prices of the appraisers were approved and the plant taken over by the city. At the same time similar action was taken on the plant of contractor for garbage collection. With these two plants the city found itself possessed of a large assortment of junk located at seven different barns or yards. As fast as possible these were consolidated into two locations; old horses replaced by good ones, repair shops located and the old rolling stock repaired. This was a slowly continued process of improvement until motorization became commercially and mechanically advisable.

The first step was in the purchase of flusher equipment for street cleaning. It was evident that no half way measures in equipment would be wise. A beginning was made with three motor tractors each drawing a 2,000-gal. tank flusher trailer, having two wheels in rear and front carried on the tractor. With these in use it was at once apparent that a proper and economical method of street cleaning had been reached. Three more were added and then nine more, making the present fleet of 15. The results, both as to cleanliness and costs, are excellent. The one improvement which yet seems desirable is a successful scraper and pick-up machine. Hand-brooming or sweeping is not in line with today's requirements. It would appear that some device of the squeegee kind with pick-up would add materially to satisfactory street cleaning.

The effect of flushing material into sewers through inlets seems to be so dependent upon grades and crowns of pavements, width of street and frequency of cleaning, as well as kind and size of sewers, that nothing definite can be said as generally applicable.

The above mentioned combination of tractor and flusher seems most appropriate in this northern city. Flushing cannot well be done in freezing weather, but upon the advent of the freezing weather the quantity of coal ashes is greatly increased and snow removel becomes necessary. This separable arrangement of tractor and flusher is then economical The flusher is housed and the tractor augments the hauling equipment when most needed.

In Buffalo during a normal snow season the automobile traffic is forced onto the car track streets unless regular snow removal is maintained on other streets. A few years ago this was of little moment; today it is vital. With the large fleet of tractors it will now be possible to fight a snowstorm from its beginning and keep all thoroughfares open. The feature of elasticity seems to make this combination the most desirable.

Minnesota State Road Contracts in 1920

Over 3,000 miles of state road work in Minnesota will be placed under construction this year, according to the tentative program made public recently by the Minnesota State Highway Department. This work includes 1,805 miles of grading, 1,530 miles of graveling and 192 miles of hard surface paving. Plans on the majority of these jobs are now in preparation, and the work will be advertised and contracts awarded during the months of January, February, March, and April, 1920, in order that road construction throughout the state may be begun early in May.

The amount and kind of work proposed in each county are given in the following table:

County.	Grading. Miles.	Grading and graveling. Miles.	Graveling. Miles.	Paving. Miles.
Aitkin		73	..	..
Anoka	..	26	..	..
Becker	..	9	..	..
Beltrami	54	70	15	..
Benton	..	8	..	17
Big Stone	7	9	6	..
Blue Earth	39	..	..	..
Carlton	..	20	..	..
Cass	..	132	..	..
Chippewa	..	25	10	..
Chisago	..	13	..	6
Clay	27	..	..	..
Cottonwood	13	..	..	..
Crow Wing	18	..	..	3
Dakota	..	31	..	1½
Dodge	..	34	..	..
Douglas	..	10	..	..
Faribault	..	32	17	..
Fillmore	2	5	11	..
Freeborn	..	46	11	..
Goodhue	..	16	..	..
Grant	5	21	..	..
Houston	.	22	..	.
Hubbard		11	.	.
Isanti	..	14	..	..
Itasca	.	..	.	65
Jackson	..	.	..	5
Kanabec	.	17	..	..
Kandiyohi	20	5	5	10
Kittson	..	13	..	..
Koochiching		12	.	..
Lac Qui Parle	.	31½	..	..
Lake		20	.	..
Le Sueur		..		1.7
Lincoln	.	28		..
Lyon	8½	51	9	..
McLeod	..	15	..	..
Mahnomen	7	22	.	..
Marshall	56½			.
Martin		16		..
Morrison	.	..	30	11
Mower	.	12	24½	..
Murray	..	18	.	..
Olmsted	11	..	11	..
Ottertail	..	15½	..	.
Pennington	4½	1½	.	..
Pipestone	..		..	12
Polk	.	62	.	1.4
Pope		18	.	..
Red Lake	..	32		..
Redwood	19½	..	32½	..
Renville		..	..	1.4
Rice	.	16	19	4
Rock	..	.		3
Roseau	.	13	..	..
Scott		27	..	.
Sherburne		..		9½
Sibley			22	.
Steele			.	7
Stevens		40	..	..
Swift		20		..
Todd		54	..	..
Traverse		30	..	..
Wabasha		1½	21	..
Wadena		8	..	..
Waseca		25	..	..
Watonwan	.	..		14
Wilkin	23	.	.	
Winona	14½	6		4½
Yellow Medicine	.	12	26	..

How to Make the "Non-Productive" Months Productive*

By HALBERT P. GILLETTE,

Editor, Engineering and Contracting.

During the winter and early spring months very little road construction is done in the northern part of the United States. Hence engineering and superintending forces are usually reduced, often greatly. The question that I raise is whether it is economically wise, in the long run, to give these men a "vacation without pay" for several months each year. Is there no practicable way of employing them continuously, and at the same time profitably?

Perhaps it is pertinent to call attention to the fact that one of the grievances of the coal miners is the lack of continuous employment. John J. Lewis, acting president of the miners' union, recently said that during the past 8 years the coal miners have averaged only 226 days worked each year, out of a total of 212 working days. This is a loss of 86 days, or about 28 per cent of the total working days. There is no escaping the fact that this is really a serious loss of time, nor can it be doubted that the public that buys the coal must foot most of the bill for this lost time. The miners suggest shorter working hours and continuous work as a solution of the problem. I will not discuss their suggestion because it is not germane to the present question. What is germane, however, is the protest of the coal miners against losing 86 days a year.

In the road building field there is a far greater loss of time than in the coal mining field. When I was in the road contracting business my equipment was busy on an average of less than 120 days a year. I doubt whether conditions have so improved that road builders in the northern part of America can count upon an average of more than 150 days worked each year.

Counting the time spent in preparing to start work in the spring and to clean up in the fall, construction engineers and superintendents probably do not average more than 8 months of outside work yearly. What is done, and what should be done, with the remaining 4 months?

In many states most of the construction engineers are assigned to surveying and drafting work during the winter. With adequate appropriations, it should be practicable thus to keep most of these engineers busy; but too often the appropriations are inadequate.

Perhaps even oftener very little attempt is made to plan surveying and drafting work in such a manner as to keep these men busy. But even if all the engineers are thus provided with useful winter work, how about construction superintendents? Must they be "fired" periodically? It seems to me that there is a better solution of this economic problem than is found in letting construction superintendents shift for themselves, as best they may, several months every year.

I offer the following as one possible solution of the problem: Let every highway superintendent be required to attend a school of practical highway construction and maintenance during the winter months, at full pay. If practicable, have him attend highway conventions where he will meet other highway builders. But, above all, seek to inculcate in him the habit ot reading current literature and books on highway work. If there are no highway schools close enough at hand, still it will be feasible to conduct a sort of Chautauqua course of reading and studying under the direction of the chief engineer.

One of the great weaknesses of most "practical men"—and unfortunately it is not confined entirely to them—is a disinclination to read systematically for information. This is a bad habit that not many of us can overcome unaided, but it is undoubtedly a habit that not only costs its possessor dear, but costs his employer dearer. As I travel about the country and see the out-of-date designs and methods in common use, my heart at times grows sick. Can it be possible that, after all that has been published about better designs and methods, these relics of the past are still regarded as being up-to-date? Are we no better than the Chinese who have no engineering literature at all? No, it is not quite that bad, for alongside the majority who seek no enlightenment we have a fairly substantial minority that do read and study. We are not all Chinese in respect of the bad habit of doing as our ancestors did. That, at least, is something gained. But consider how vastly greater our total effectiveness would be were every one of us to apply the best available method or machine.

Luther Burbank, in his monumental twelve-volume book, says that if every farmer would plant the best seeds and use the best methods of bringing them to fruition, the output of the average farms could be tripled without increasing the present acreage or the number of men engaged. It is my belief that an equal increase in the efficiency of the average road builder can be secured in a similar manner. But ignorance coupled with lack of adequate incentive hold us back in the highway field as everywhere else. There is some ignorance always at the top of every organization, but that is as nothing compared with the ignorance all the way down the line, culminating in the gross stupidity of the laborer who shirks his work to "make the job last."

If I am measurably right, the four "non-productive months" of the year can be so used as to make them, by all odds, the most productive months of the year; for nothing that a man does is so productive, in the long run, as is learning the very best methods of production.

Motor Vehicle's Share of Costs of Road Construction and Maintenance*

By S. E. BRADT,

State Superintendent of Highways of Illinois.

The question propounded in the topic assigned to me is one calling for the judgment of each individual, and his answer will be governed to a certain extent by conditions existing in his own state; therefore, what I shall say may not exactly apply to all states, but will serve, nevertheless as a basis for discussion.

Three Factors in Levying Taxes.—The underlying principle of taxation is that the taxes shall be levied as far as possible in proportion to the benefits received. Its practical application however, involves levying the taxes upon those who have the money with which to pay. In levying taxes for highway improvement it must be done in a manner that will meet the approval of those who are to pay the taxes, for the reason that any extraordinary expenditure has to be approved by the people at the polls. The more nearly these three factors, namely, levying the taxes according to benefits received, upon the people who have the money, and with the approval of those who pay, can be merged into a plan of taxation, the more equitable and the more successful the plan will be.

We naturally come back to the oft discussed question as to who receives the benefits from road improvement. That there is a general public benefit to our entire citizenship, applying equally to those who do not use the roads as well as to those who do, is beyond question.

In addition to the general indirect benefits to all the people, there are direct and pecuniary benefits accruing to the users of the road. These arise from a saving of time to the car owner, a saving in wear of tires, a saving in repairs and in gasoline consumption, as well as from the added life of the car itself.

What these direct benefits to each car owner will average annually is a question over which there may be considerable difference of opinion. I think I am safe in saying, however, that there are very few people who will not place these benefits greatly in excess of the license fees charged at the present time by any of the states. So long as these fees do not exceed these directs benefits the tax is just and the motorist is not being harmed.

The Illinois Plan of Taxing Motor Vehicles.—The motor license fees in Illinois averaged approximately $5 per car in 1917. In 1918 the fees were increased to an average of about $7 per car and in 1920 the fees will average $10 per car. This fee will produce about $5,000,000 in 1920, which has already been appropriated as follows: for maintenance, $200,000, and the remainder to be expended on federal aid roads in connection with federal money. This, however, is not all that is provided for road work in Illinois. During the same period there will be raised by general taxation through county and township levies about $15,000,000, or three times the amount received from motor license fees. In other words, the motorist because of the direct benefits he receives will be called upon to pay $5,000,000, while the general public, including motorists, will pay $15,000,000 because of these direct benefits. I do not believe this represents the correct ratio between the direct and indirect benefits of road improvement and I am of the opinion that there is considerable room for further increase in motor fees before we reach the right proportion. The above increases, however, serve to show the evolution in legislation and the change in public sentiment towards levying a larger tax on the motor vehicle.

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*From the December Highway Magazine.

*From a paper presented Dec. 8 at the convention of the American Association of State Highway Officials.

Let us come back to the two practical factors in the problem of taxation mentioned above, namely, getting the money from the people who have it and getting it with their consent. The motorist not only has the small amount of money with which to pay his annual motor license fee, but he is willing, even anxious to approve any reasonable license fee that will bring about highway improvement. More than this, he is willing to pledge the payment of these fees over a long period of years as a basis for the payment of bond issues to be used for highway improvement. As evidence of this I would call attention to the fact that in Illinois the voters approved a $60,000,000 bond issue for highway improvement by a vote of 661,815 to 154,396, with the provision that the bonds and interest would be paid entirely from the motor license fees, which required a 100 per cent increase in those fees. Approximately one-third of the voters were motorists, and the most enthusiastic supporters of the proposition throughout the state were these motorists. I do not think that the people of Illinois differ very materially from the people of other states in their attitude towards questions of this kind. Therefore, what can be done in Illinois can be done anywhere.

For this reason I do not hesitate to say that if motorists can be assured that the money is to be properly expended they stand ready to give their approval to any reasonable, direct tax on motor vehicles for highway improvement.

The Reason for Motor Vehicle License Fees.—A great public necessity which would require an unusually large expenditure often calls for a change in our method of taxation. Undoubtedly the license fees were inaugurated because of the excessive damage to the existing macadam roads by automobile traffic. The increased motor traffic made it apparent that these roads not only must be maintained, but that thousands of miles of additional roads must be surfaced. The amount of money required today to improve sufficient roads to meet the demands of public sentiment throughout the United States runs into billions of dollars. To add the amount thus required to the present heavy general taxation would undoubtedly result in failure in many of the states; but if the motorist is willing to assume a reasonable proportion of this cost through motor license fees, to go direct to road improvement or to the payment of bonds for road improvement, I believe the money can be provided as rapidly as the country can find labor, materials and transportation to carry on the work. The placing of a reasonable proportion of the cost of construction and maintenance of our highways upon the motorist is not only equitable but will make the task of raising the money comparatively easy.

Application of Funds from License Fees.—There has been much discussion over the question "whether motor license fees should be used for construction," some people holding to the view that this fund was intended for maintenance only and should be confined to that single purpose. In Illinois a dollar looks just the same whether derived from general taxation or from motor license fees; and whether it should be used for one purpose or the other, or both, is a matter to be determined by local conditions. Maintenance is absolutely essential, and if a state requires for maintenance of its roads the entire amount derived from motor license fees it is perfectly proper to devote it entirely to that end. If it requires only a part of the fees for maintenance then why not devote the remainder to construction? Our policy should be to charge a reasonable fee somewhat in proportion to the direct benefit received and then use the money to the best advantage and where it will do the most good.

There is another phase of the problem of taxing motor vehicles; that is, that it will ultimately reach a very large percentage of the taxpaying population. Several of the states at the present time have an average of one vehicle to every six or eight of the population. Illinois at the present time has one car to about every twelve people, but the present increase indicates that by 1923 we shall have one car to every eight people. This means an average of nearly one car to a family. Therefore, while the motor license fee taxation will not be uniform as to the valuation of property, it will be fairly equivalent to a general taxation on the basis of the population.

Basis for License Fees.—I wish to say that it is generally recognized that horsepower rating as a basis for motor license fees is not equitable. The man who drives his Ford car 1,000 miles in a year pays the same fee as the man who drives the same car 20,000 miles in the same length of time. The man driving the 1,000 miles should undoubtedly pay more in proportion to the mileage traveled than the man driving the 20,000 miles, but his total annual tax should not be the same.

We are all waiting for some ingenious individual to work out a more equitable plan, such as a graduated gasoline tax—by which each vehicle would pay a fee in proportion to its weight and the mileage driven; that is, in proportion to its actual use of the road.

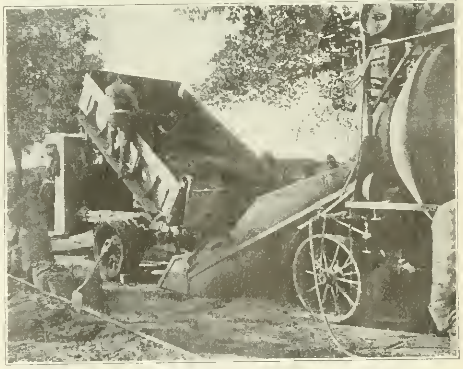
The demand which we are now facing for highway improvement, calling for a volume of money never before dreamed of in any scheme of internal improvement, places us in a position where we shall be obliged not only to use the old established methods of raising money, but to resort to any other equitable plan which may be devised. The raising of funds for this work by a license fee to be paid by the individual who uses these highways and receives a large direct benefit from this improvement, is surely an equitable and proper source of revenue, and the benefit is so pronounced that the motorist stands ready to offer this assistance.

As has been indicated, the proportion which the motorist should pay towards highway improvement and maintenance will differ in almost every instance because of varying conditions. The proportion will to a large extent be determined by the license fees charged. If fees are based on benefits to the motorist, it is apparent that the greater the mileage improved or maintained, the greater the benefits; that is, the broader the scale of your plans the larger should be your license fees.

These matters are for local determination in accordance with local conditions and local public sentiment.

Truck with 5-Compartment Body for Hauling Concrete Aggregate

Motor trucks having 5-compartment bodies were used by the Charles F. Fry Construction Co., Erie, Pa., for conveying aggregate to the mixer for a state highway contract west of Erie, Pa. The sides and front of the box are raised to the same height as the top of the dividing partitions. This prevents the sand running over the sides of the body or into the next compartment, when the body is raised for dumping. The dividing partitions are hung on pivots located at the top of the sides of the body.


5-Compartment Motor Truck Body for Hauling Sand and Gravel.

The truck was used in the following way: The sand and gravel were unloaded from the gondola cars by a crane and clam shell bucket. The crane deposited the material in either storage piles or directly into large timber bins. The bins were equipped with trap doors in the bottom and the materials ran into measuring hoppers. Each hopper had a capacity of 8 cu. ft. of sand and 12 cu. ft. of gravel—sufficient material for a 4-bag batch of 1:2:3 concrete. There was sufficient overhead clearance under the bins and hoppers for the truck to stand. A full batch of sand and gravel was deposited into each compartment of the truck. The original idea was to add the cement requirements at this point also. This was not found practicable however, because at times the sand and gravel contained some moisture which caused the cement to take its initial set before arriving at the mixer. Accordingly thereafter the cement was added at the mixer.

In operation the truck was run out on the grade backed up to the mixer skip and the first compartment tripped and dumped into the skip. The four bags of cement were added. It was then necessary to drive the truck ahead a few feet to allow clearance for raising and dumping the skip into the mixer drum. The truck was delayed about eight or ten minutes at the mixer while the four batches were mixed. The fifth and last batch was then dumped and the truck returned for another load. The arrangement was described in the December Contractor's Atlas from which the matter given above is taken.

New Gramm-Bernstein Truck Line for 1920

The Gramm-Bernstein Motor Truck Co., Lima, O., is announcing a new line of motor trucks for the year 1920 which have been entirely redesigned after a careful analysis of the Class B Liberty Truck. The new line consists of six models, including a 1½-ton internal gear, and worm driven models in 1½, 2, 2½, 3½ and 5-ton capacities.

New 5-Ton Model.

The 1½ ton internal gear, known as Model 15, has been built, so the manufacturers claim, to round out their line and fill the demand for a strictly high grade truck of 1½ ton capacity to sell at a popular price. It is driven by a Continental "N" motor and uses a conventional type transmission with a Clark internal gear axle. The Gramm-Bernstein line of worm driven trucks has as its basis their new 5-ton model known as Model 50. The 2½, 3½ and 5-ton capacities are driven by Liberty truck type motors. The 1½ and 2-ton models are equipped with the latest type Continental motors. One of the important features of the Gramm-Bernstein worm drive line is the fact that they are regularly equipped with a standard cab with doors, ventilating windshield, motometer, radiator guard, radiator shutters and shroud, army towing hooks, hub-odometer, metal license brackets front and rear, spring trailer drawbar supported in frame by extra A member, electric generator, storage battery, lights and horn.

State Highway Work in South Carolina.—The State Highway Commission in its annual report states it is expected that 400 miles of the state highway system will be improved in 1920.

Personals

W. J Dermott has been appointed city engineer of Radford, Va.

Orrin W. Head has been appointed superintendent of streets for Concord, N. H.

Walter W. Massie has been appointed city engineer and highway surveyor of Cranston, R. I.

Col. W. D. Solner, for the past eight years chairman of the Massachusetts State Highway Commission, has resigned.

D. W. Jones has resigned as district engineer of the New Mexico State Highway Department to accept the position of secretary of the Chamber of Commerce of Clovis, N. Mex.

R. M. Morton has been appointed engineer of the San Diego County, California, Highway Commission and will have charge of the construction of roads under a $2,300,000 bond issue.

E. H. Davis, formerly city engineer of Griffin, Ga., and for the past two years an inspector in the State Highway Department, has been appointed chief engineer of highways in the Sixth Congressional District, with headquarters at Griffin.

Metcalf & Eddy, consulting engineers, Boston, Mass., announce that Frank A. Marston has been admitted to the firm as a junior partner. Mr. Marston is a graduate of the Worcester Polytechnic Institute and has been with Metcalf & Eddy since 1907.

J. W. Lediux announces that, in order to adequately take care of his consulting engineering practice, he has resigned as chief engineer of the American Pipe & Construction Co., and will, from and after Jan. 1, 1920, be established as consulting engineer with offices at 112 North Broad street, Philadelphia. He will specialize in water works, valuation, arbitration, rate cases and water power development.

The State Highway Department of Pennsylvania has reorganized its forces in the field and has increased the department districts from 15 to 18. Under the reorganization the 18 districts of the state are in charge of the following district engineers: District No. 1, D. C. Stackpole, with headquarters at Bellefonte. District No. 2, C. W. Erisman, Harrisburg; District No. 3, H. G. Harper, Bloomsburg; District No. 4, C. H. Buckius, Franklin; District No. 5, C. E. H. Smith, Allentown; District No. 6, George W. Crawford, York; District No. 7, Maj. C. E. Myers, Philadelphia; District No. 8, Paul Brubaker, DuBois; Distict No. 9, Capt. George P. Searight, Harrisburg; District No. 10, Capt. J. S. Ritchey, Wellsboro; District No. 11, Charles S. Lemon, Hollidaysburg; District No. 12, S. P. Longstreet, Scranton; District No. 13, W. D. Meyers, Pittsburgh; District No. 14, Charles Fitzsimmons, Washington; District No. 15, Capt. F. E. Winter, Warren; District No. 16, M. A. Lynch, Smethport; District No. 17, H. R. Moffitt, Wilkes-Barre; District No. 18, A. K. VanIngen, Bedford.

H. R. Abbott, civil and sanitary engineer, Chicago, has organized an engineering-construction company for the purpose of specializing in the building of water supply, water purification and sewage disposal plants, the field of operation to be in Illinois and neighboring states. Office has been opened at 1118 Chamber of Commerce building, Chicago. Mr. Abbott completed his government work in the construction division of the army in November after two years' service in the sanitation section on design and construction of sewer systems and sewage disposal plants at army camps, principally throughout the southern states. Later he was assigned to Fort Sheridan, General Hospital No 28, as supervising engineer in charge of installation of sewage disposal and additional water supply plants. For several years prior to his government service he was an assistant engineer with the Sanitary District of Chicago in charge of large intercepting sewer construction and previously had charge of construction of extensions to the Metropolitan Elevated Railway of Chicago.

Industrial Notes

Hugh L. Siegel, formerly general sales manager for the Ford Roofing Products Co., is now with Walter A. Zelnicker Supply Co. as assistant to the president.

The Cleveland Tractor Co. has opened a show room in the Goodrich Rubber Co. building, 1780 Broadway, New York City. F. R. Bump is district sales manager.

The Richardson-Phenix Co., lubrication engineers and manufacturers, Milwaukee, Wis., has opened an office at 306 American Trust building, Birmingham, Ala., with Jas. D. Scruggs as district manager.

Edward D. Kilburn, who since March 15, 1917, has been New York district manager of the Westinghouse Electric & Mfg. Co., was recently elected vice-president and general manager of the Westinghouse Electric International Co.

I. F. Baker of the Westinghouse Electric International Co., who has been located in the New York office of that company for the past two years, is now on his way to Tokio, Japan, where he will act as a special representative of the Westinghouse International Co.

Announcement has just been made by the Smith & Sons Mfg. Co., Kansas City, Mo., manufacturers of the Royal line of road building machinery that the George W. Zeigler Co., Pittsburgh, Pa., has contracted for the entire Royal line in the Pittsburgh territory.

The Pittsburgh-Des Moines Steel Co., formerly Des Moines Bridge & Iron Co., Des Moines, Ia., has started work on improvements at its Des Moines plant, which will consist of a new shop building 135 by 300 ft., equipped with traveling cranes and modern equipment for the fabrication of structural steel. This improvement when completed will cost in excess of $100,000. It is expected to have the improvement complete and ready for operation by early spring. When completed the Des Moines shop will have a capacity of about 1,200 tons per month.

F. F. Fitzpatrick, who has been appointed manager of the asphalt sales department recently created by the Sinclair Refining Co., has had a wide experience in the general asphalt and petroleum business, both in this country and in the republic of Mexico. He has been identified with the Sinclair Refining Co. for the past year and a half, having joined the organization originally as manager of the refinery sales department and for the past several months has been assistant sales manager of the general oil section of the business. J. M Woodruff, assistant manager of the asphalt sales department, was formely manager of the paving and publicity departments of the Standard Asphalt & Refining Co. He has been identified with the marketing and use of asphalt in pavement construction in the central and southern states for the past ten years, assisted in organizing the Southern Asphalt Association of Atlanta, Ga., and resigned as general manager of that association to accept the position with the Sinclair Refining Co.

Waterworks and Hydraulics Monthly Issue

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The four rotated special monthly issues and 4 quarterly issues of E. & C. (52 in all) entirely cover the civil engineering and contracting field at $3.00 a year. The special quarterly issues relate entirely to foreign engineering and construction practice. The *articles* in the first two issues of each month completely cover the municipal engineering and contracting field. The *articles* in the first and fourth issues of each month completely cover county engineering and highway engineering and contracting. The *articles* in the 3rd and 4th issues of each month completely cover steam and electric railway location, design and construction. See the "masthead" on the first page of the Weekly News Section for information about our weekly contract news.

Roads and Streets—1st Wednesday
(a) Roads
(b) Streets
(c) Street Cleaning
(d) Municipal Miscellanies
(e) Management and Office System

Waterworks and Hydraulics—2nd Wednesday
(a) Waterworks
(b) Sewers and Sanitation
(c) Irrigation and Drainage
(d) Power and Pumping
(e) Management and Office System

Railways and Excavation—3rd Wednesday
(a) Excavation and Dredging
(b) Rivers and Canals
(c) Quarries and Pits
(d) Railways, Steam and Electric
(e) Management and Office System

Buildings and Structures—4th Wednesday
(a) Buildings
(b) Bridges
(c) Harbor Structures
(d) Miscellaneous Structures
(e) Properties of Materials
(f) Management and Office System

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E. & C. Index Furnished Only on Request

The Index for Vol. LII—July-December, 1919—issues of Engineering and Contracting is now being prepared. In common with many other publishers we have adopted the practice of sending the index to only such subscribers as request it. Therefore, if you want the index for the last 6 months you should notify us at once. Those who requested the index for the previous volumes have been listed and need not notify us again.

Defining Words, Exemplified by Engineering

The "Committee on Development" recently submitted to the American Society of Civil Engineers four suggested definitions of engineering. They are:

(a) Engineering is the science and art of directing the great sources of power in Nature to the use and convenience of man.

(b) Engineering is an art and science. It is a science in so far as physical laws are its base, and an art in so far as in the application of these laws the things designed and constructed develop the spirit of progress, the creation of wealth, and the well-being of all peoples.

(c) Engineering is the creative science and art of applying economically the materials and forces of Nature to the use and convenience of man.

(d) Engineering is the science of industrial effort, and the science and art of applying this effort for the welfare of the public.

A definition is a brief specification of a class. Stated more fully: A definition is a proposition that indicates the significance of a class name by designating a sufficient number of its attributes to insure identification of any member of the class. A well framed definition contains no superfluous words, and it specifies no attributes that are not used in identifying a thing as being a member of the class defined. It includes every member of a given class and excludes whatever is not a member of that class.

There may be many good definitions of the same thing. One group of attributes may be used in one definition, another group in another definition of the same thing, and so on. The attributes to be used depend upon the knowledge of those for whom the definition is framed, as upon the nature of the general subject to be discussed. Thus, a chemist might define water as being a molecule composed of two atoms of hydrogen and one of oxygen; whereas a teacher of a kindergarten class might define water as being "the stuff you ordinarily wash your hands and face with."

So in criticising any definition, care should be taken to ascertain for whom it is formulated and in what connection it is to be used. But this should not prevent inquiry and discussion as to whether a

28 Pages=40 pages

The 28 pages of articles in Engineering and Contracting contain as many words as 40 pages of the size and typography commonly used by other engineering periodicals. Ours is the same size of type and type-page as that of The Literary Digest—easily read, yet giving a large volume of reading matter per page. Our 28 pages of articles would fill 112 pages of the standard 6x9 in. text-book. It would take 10 such books of 580 pages each to hold all the articles printed each year in Engineering and Contracting, to say nothing of our weekly construction news.

given definition is the best for a given purpose, nor should it exclude criticism of a definition on the ground of its containing superfluous words or ideas. Even inelegant combinations of words, and injudicious selection of synonyms may constitute objections to a given definition.

Let the reader consider each of the four definitions of engineering above given, having in mind the principles just stated.

Take definition (a). Is it necessary to include the word "art" in a modern definition of engineering? What is an "art," as here used? The old logicians and philosophers divided knowledge into two classes: (1) Art and (2) Science. But they were by no means agreed as to a definite dividing line between the two.

In an appendix to his Logic, Prof. Bain gives several systems that have been proposed for classifying knowledge, beginning with that of Francis Bacon and ending with that of Herbert Spencer. It is noteworthy that in the early days the word "science" was applied only to "pure science," whereas the word "art" included what we now call "applied science." Thus mathematics was a "science," while engineering in all its branches was an "art." Obviously we no longer use these two words in that old sense, for we regard engineering as a science: an applied science. If so, what place is left for the word "art" in a modern definition of engineering? Shall we use it to designate skill resulting from practice? Hardly, because skill is a relative term that is itself impossible to define with sufficient definitness to enable any one to use it as a criterion of an engineer; moreover, engineering itself can not be spoken of as possessing skill.

Engineering is a branch of applied science. If "art" is applied science, the word "art" is superfluous in a definition of engineering. If "art" is not applied science, then it devolves upon those who urge the retention of the word "art" to define it in such a way as to make clear the desirability of using it as a part of a definition of engineering.

Of course we are aware that "art" has been used to mean a code of rules for the application of the principles of science. But any such use of the word "art" at once raises the question as to whether applied science is not itself a code of rules. This raises the further question as to what science itself is.

"Science," says Prof. Bain, "groups together facts and generalities of a kindred sort . . . and presents its materials in a fitting arrangement." Broadly speaking, a science is a comprehensive code of classified principles together with classified rules and data for their application. We may, if we please, segregate the principles and call them "pure science"; we may segregate the rules or methods and call them "applied science"; and we may segregate the "data" and call them by any name we please. But whether in teaching a science or in applying it, we must make use of at least some principles, some rules or methods, and some data. This holds true of mathematics, which is the typical "pure science," as it holds of accountancy, of surveying, of road engineering, or of any of the numberless branches of so-called applied science. Then, why, we ask, is there any need of prolonging the life of that practically useless word "art" in reference to engineering or to any other applied science?

Definition (a) names the "great sources of power in Nature," which is Tredgold's grandiloquent, old expression a phrase that contains six words to express what can be as well expressed with one or two, namely "power," or "natural power." The adjective "great" is purely relative, and it is really not descriptive of all the "powers" that engineers direct, as, for example, the relatively small power of capillarity, a knowledge of which is important in irrigation engineering.

"To the use and convenience of man" is another of Tredgold's expressions. It is here used as a peculiar attribute or "mark" by which to distinguish engineering from other applied sciences and arts. As such it is worthless. With as much propriety might gravitation be defined as the power that causes all masses to move, or tend to move, toward one another, throughout the universe. Here the last clause is redundant, because it adds nothing that is not already expressed by the word "all." Similarly when defining a science or art, there is not the slightest need of specifying that it is for "the use and convenience of man," because that is the object of every art and science. Even the destructive science of military engineering has this characteristic; it is applied for the "use and convenience of man." True, it is that in serving some men military engineering injures and destroys others. Hence it may be argued that because it does not serve all men—"man"—military engineering should be excluded as a branch of engineering. Not only would such an exclusion be arbitrary but it would rest, in its ultimate analysis on an ethical motive. Who is competent to pass judgment on such motives?

It seems evident to us that in writing his ancient definition of engineering, Tredgold introduced the expression, "for the use and convenience of man" in order to emphasize an altruistic or ethical conception of engineering. We do not contend against such a conception, but why attempt to use it as a distinguishing characteristic or "mark" of engineering? Its use may perhaps serve the purpose of creating in the public mind a conception of engineering as being peculiarly altruistic. This would have some advantages and some disadvantages. As high priests of applied science, we might be taken at our own appraisement and continue to be permitted to receive most of our rewards in heaven for services performed on earth. Judging from the loud protests that most professional engineers are raising against their present salaries, the majority do not yet favor being regarded too literally as being extreme altruists.

Fifteen years ago, in his Handbook of Cost Data, the editor published a definition of engineering, which, slightly altered as to phraseology, but not as to meaning, is as follows:

Engineering is the systematic and understanding application of science to the problems of economic service.

This definition certainly includes everything that is commonly called engineering. At the time it was first published it was regarded by many engineers as being too broad a definition, in that it included certain things not then commonly called engineering. Management engineering, or the application of the science of management, was long regarded by the great majority of engineers as being an activity not entitled to be classed as engineering. Such conservatism, however, was not a new phenomenon; for chemical engineering and agricultural engineering had been previously rejected from engineering by the conservatives, only to be admitted later by the progressives. Similarly today we find almost every radically new branch of engineering denied professional admission to the group of older engineering activities. For example, in the presence of civil engineers let a man call himself a publicity engineer if he wishes to hear his right to the title challenged on all sides. It matters not that a publicity engineer has carefully studied the science of psychology for the purpose of applying it in selling services or goods. It matters not that he has developed an elaborate system of methods and has accumulated a vast amount of classified data for his special purposes, still he is no engineer in the eyes of the older members of the engineering profession.

Of course it is permissible to restrict the meaning of any word as much as may be desired—provided many men will join in the proposed restriction. On the other hand, the meaning of a word may be extended—provided many men will join in extending it. Or the meaning of a word may be broadened in certain respects and coincidently narrowed, in certain other respects. It seems to us the part of practical wisdom so to define "engineer" as to exclude those that do not apply scientific principles that they themselves understand. This would exclude uneducated enginemen. On the other hand, it seems wise to extend the old meaning of "engineer" to include all men who systematically and understandingly apply any science in solving the problems involved in rendering any economic service.

Among the incidental advantages of this conception of engineering are these:

(1) A rapidly growing recognition by the public that engineering can help them in countless ways; that engineering is not necessarily a recondite, theoretical and "highbrow" subject, but that its aims are practical, its methods often very simple and always preferable to systemless attempts at solving the problems of industry, commerce and politics.

(2) A steadily widening field for the graduates of our engineering colleges, thus tending to eliminate excessive professional competition.

(3) The development of community of spirit and of purpose among large groups of educated men, as a consequence of belonging to a common profession—engineering. By welding several hundred thousand men of scientific training into one engineering organization, vastly more can be accomplished than by their remaining apart under titles that fail

to show their real kinship, and thus fail to inspire them to cooperative action.

The Illogical Conclusions of Many Engineers Respecting Depreciated Value

The value of any plant is equal to its prospective annual net earnings divided by the rate of interest, which is the "capitalized net earnings."

Let

v = value of the plant A.
V = value of the plant B.
g = prospective annual gross earnings of plant A.
G = ditto of plant B.
e = prospective annual operating expense of plant A.
E = ditto of plant B.
r = the rate of interest.

Then

$$(1) \quad v = \frac{g - e}{r}$$

whence

$$(2) \quad g = rv + e$$

$$(3) \quad V = \frac{G - E}{r}$$

whence

$$(4) \quad G = rV + E.$$

If the two plants have the same prospective annual gross earnings, or $g = G$, then (2) becomes

$$(5) \quad G = rv + e.$$

Combining (4) and (5) gives

$$(6) \quad rv + e = rV + E$$

whence

$$(7) \quad v = V - \frac{e - E}{r}$$

If plant A is one whose value is unknown, whereas it is known that plant B can be purchased for K dollars, then $V = K$, and equation (7) becomes

$$(8) \quad v = K - \frac{e - E}{r}$$

Equation (8) gives the value of any plant, provided the prospective gross earnings from it is the same as from another plant whose market value is known to be K.

If $e = E$, then $v = K$, which means that the value of any plant is the cost of a substitute plant, when the prospective gross and net earnings are the same for both plants.

Usually, however, e and E are not equal; in which case eq. (8) is to be used.

Equation (8) is the only correct formula for the depreciated value of any uplant or for any plant unit where the gross earnings are not affected by substituting one plant or one plant unit for another.

Note particularly that equation (8) does not contain a factor that represents the original cost of plant A whose value is v; but that it does contain the present market price (K) of the plant B. If, for example, the present market price (= cost) of a new, modern boiler (B) is K, and if it performs the same service as an old boiler (A) then we see from eq. (8) that the depreciated value (v) of the old boiler (A) is equal to the cost (K) of a new boiler (B) of equal capacity minus the capitalized difference in their prospective annual operating expenses (e and E).

Where gross earnings are unaffected this is the only logical formula for determining the depreciated value of a plant unit, yet there are many engineers who still think that depreciated value can be ascertained by deducting something from the original cost of an old plant unit! That would be "depreciated cost," if such a thing existed, and not depreciated value; but there is, in reality, no such thing as "depreciated cost."

Equation (8) is a special case of a more general formula called "the unit cost depreciation formula" given in the Handbook of Mechanical and Electrical Cost Data by Gillette and Dana. The appraisal committee of the American Society of Civil Engineers declared the "unit cost depreciation formula" to be logically correct. If so, all other formulas that yield different results must be incorrect.

When an engineer deducts from the actual cost of a plant unit purchased at pre-war prices a sum that he states is accrued depreciation, he is therefore wholly illogical. Yet this illogical act is being committed by many engineers.

Equation (8) may be used not only for calculating depreciated value, but for estimating the value of land, water rights etc. There are certain precautions to be observed in applying the formula, such for example, as are involved in selecting a correct value for the interest rate (r). Engineers frequently make the mistake of using bond interest rates for capitalizing annual earnings or expenses. We need only mention this in passing, for the precautions to be observed are fully discussed in the book above named.

Book Reviews

Hydrology, The Fundamental Basis of Hydraulic Engineering.—By Daniel W. Mead, M. Am. Soc. C. E., Consulting Engineer, Professor of Hydraulic and Sanitary Engineering, University of Wisconsin. McGraw-Hill Book Co., New York. Cloth; 6x9 in.; illustrated; 647 pp.; $5.

Professor Mead has condensed his observations, taken from 35 years' experience, into a volume which contains a wealth of information on the facts and principles of hydrology. The subject matter may be grouped somewhat arbitrarily under four main headings: general conditions affecting hydrology, precipitation, geology and underground water resources, and stream flow. Under general conditions affecting hydrology, are treated wind and storms, ocean and lake currents, waves, tides, and other meteorological fundamentals. Atmospheric moisture and evaporation are thoroughly discussed.

Precipitation, the source of all water supplies, naturally receives very extensive treatment. Minimum as well as maximum rates of rainfall have a very important bearing on hydraulic engineering. Both may cause loss of life ultimately and too great an emphasis cannot be laid on the study of precipitation records. Geology and its effect on underground supplies has not been neglected as three chapters are devoted to this subject. Water as a geological agent is discussed and through such study a comprehension of the birth, growth and development of drainage systems and rivers is attained.

Stream flow or run-off, an all-important subject in hydraulic engineering, is presented as the result of all of the preceding contributing factors of hydrology. It summarizes for the engineer the necessity of keen observation of all of the forces of nature. Methods for estimating run-off, factors which influence stream flow, the importance of flood studies, the determination of storage are a few of the subjects presented.

As a conclusion, the author has outlined briefly some of the applications of hydrology. Two general classes of engineering work in which it plays an important part are considered: works for the utilization of water, and works for the control of water. Abundant references to correlated articles are furnished. As a whole, this work may be considered almost an encyclopedia, yet possessing all of the usefulness of a handbook.

Oriental Methods of Raising Water.—The oriental methods of raising water are often extremely efficient, according to an article in the November Journal of the Royal Engineers. The Shadouf (Arabic), Dhingly (Hindustani) consists of a bucket hung by a rope to a swinging pole weighted at the end opposite to that to which the bucket is attached. This is capable of an average of upwards of 1,500 gals. per hour from a depth of some 6 ft.—the capacity entirely depends on the skill of the operators, and natives are far more adept than Europeans can ever become. Sakkieh (Arabic), Arrat (Hindustani) is capable of some 3,000 gals. per hour at 40 ft. depth. It may be operated by men, oxen, camels, horses, mules, etc. This is the "Persian Wheel." Chursa, used in India and Mesopotamia, capable of upwards of 1,500 gals. per hour at 40 ft.

Michigan Drainage Commissioners to Meet.—The State Drain Commissioners' Association of Michigan will meet at Kalamazoo, Mich., Feb. 3-6.

Generalizations and Their Relative Value

By HALBERT P. GILLETTE, Editor.

Knowledge of the meaning of words is usually acquired either by their direct association with the things that they symbolize or by their association with other words in such a manner that their meaning is inferred. Even educated men seldom learn many words by studying printed definitions, and still less frequently by formulating their own definitions.

Words are merely symbols of ideas, and ideas are "mental pictures" of things. If a person has clear mental pictures he may reason correctly even though he may be unable to define the words that he uses. But inability to define a word is a danger signal, especially when the word relates to an abstract idea, for such inability often indicates a vague conception of the thing that the word symbolizes. No argument is needed to prove that vagueness of conception is a common cause of misconception. It is suprising, however, to learn that many of our conceptions of the meaning of commonly used words are vague. This is notably the case with words that denote different classes of mental actions. Take the words generalization and principle, for example. Every scientific man uses them repeatedly, yet how often can they be correctly defined? Write definitions of them now, and test the definiteness and completeness of your conception of them.

Generalization.—A mental generalization is a mental record of a relationship between two or more classes of things, an exact duplicate of which may be made by substituting members of the same class for one another.

The last clause of this definition may be omitted whenever it is understood that every class name itself implies the substitutional character of the members of the class, and can be used without implying that the name refers to all the members of the class regarded collectively as a group.

"Mental records" are commonly called ideas, or mental "pictures." For present purposes no further discussion of them is necessary. The word "relationship," however, needs brief discussion.

Relationship.—Two things are related when there is one fact or series of facts into which both enter. Relations may be broadly classed thus:

(1) Qualitative
    (a) Sequential
    (b) Coexistent
(2) Quantitative
    (a) Sequential
    (b) Coexistent

Every conceivable relation may be placed in one of these broad classes; but there is an endless number of minor classes or subclasses of relationships. Among sequential relations are those of cause and effect. Among coexistent relations are those of subject (= mind) and object (= matter).

Mental "pictures" may be moving or stationary. Moving "pictures" embrace sequential relations. Stationary "pictures" embrace coexistent relations.

Every relationship falls under one of two broad classes: (1) Likeness and (2) Unlikeness.

Verbal Generalization.—A verbal generalization is a group of words that symbolize a mental generalization. The word generalization is commonly used to designate only a verbal generalization, and in deference to custom I shall use it in this sense whenever no misconception is probable.

Words are not the only means of expressing a mental generalization. The earliest written words were abbreviated pictures, from which evolved the hieroglyphics and thence the letters that combine to form words. Algebraic symbols are often used to express quantitative relationships between classes of things; for example, $H^2 = P^2 + B^2$ is a generalization expressing a relationship between three parts of a right-angle triangle, each part being a subclass.

Verbal generalizations are a subclass of symbolic generalizations. Back of a symbol is a mental record (if the symbol means anything), and back of a mental record are the things that caused it.

Logicians have long been accustomed to point out that generalizations (meaning verbal generalizations) are rarely complete and that certain "conditions" are implied even when not stated. It is obvious that this statement is equivalent to an admission that verbal generalizations are merely symbolic of mental generalizations. Take the generalization "Snow is white." This does not mean that snow is always white. In a perfectly dark room snow has no color and is black. This verbal generalization therefore tacitly assumes that sunlight, or its equivalent, is present; and of course the complete mental picture embraces this element—light.

A verbal generalization expresses a relationship between at least two classes of things. What is a "class"? What is a "thing"? Let the reader write his definitions of these words.

Class.—A class is a number of things that are indistinguishable from one another in respect of one or more effects. In other words, one member of a class can be substituted for any other member without changing any effect that characterizes the class.

In the final analysis every class is an energy or group of energies of which there are duplicates. This conception will be explained fully in later articles.

Classes are said to have characteristic attributes or "marks." Attributes, however, are themselves classes of things. "Snow is white" is equivalent to "Snow possesses whiteness." Whiteness is a class of effect upon the brain, produced through the eye and the optic nerves.

A member of a class may be persistent (= an object) or it may be recurrent (= an event). Carbon and oxygen are persistent classes. Combustion is a recurrent class of thing. An animal is a persistent class; its hunger, pain and pleasure are recurrent classes.

A later article will relate to classes and systematic classification, hence this brief introduction will suffice for present purposes.

Thing.—The word thing is frequently used to designate persistent things, or objects only, but commonly it has a broader significance. Thus we hear it said that "selfishness is a detestable thing." Even imagined creatures, such as mermaids and centaurs, are called things. Therefore we may define a thing to be any energy or force, simple or complex, objective or subjective.

Qualified and Unqualified Generalization. An unqualified verbal generalization commonly contains the adjectives "all" or "every," or the adverbs "always" or "invariably," or their equivalents; but these signs of unqualified generality are often omitted where they are evidently implied. The following six verbal generalizations indicate precisely the same mental generalization: (1) All diamonds are combustible, (2) Every diamond is combustible, (3) Any diamond is combustible, (4) Diamonds are always combustible, (5) The diamond is invariably combustible, and (6) Diamond is combustible.

A qualified verbal generalization commonly contains the adjectives "some," "many," "most," or the adverbs "sometimes," "frequently," "mostly," "usually" or their equivalents. Thus (1) Some leaves are green, (2) Many leaves are green, (3) Most leaves are green, (4) Leaves are sometimes green, (5) Leaves are frequently green, (6) Leaves are usually green.

A qualified generalization either implies or asserts that a more complex class of thing is involved than the one named. Thus, "Some vertebrates are men" implies that man is a complex class; that is, subclass of vertebrate. "Most, but not all, leaves are green" asserts that leaves are divisible into subclasses most of which are green.

A qualified generalization frequently is worded as if it were unqualified, it being assumed that knowledge of the conditional factors is so nearly universal that they need not be explicitly stated. Thus, "Individual efficiency increases when the pecuniary reward for effort is proportional to the output of the individual." This generalization is unqualified in form but qualified in fact. It is tacitly assumed that the average or typical worker in a modern civilized society is referred to. In short, it implies a subclass of workers, and does not necessarily hold true of all workers. Workers who are utterly unselfish, or completely altruistic, would not fall within the scope of this "law of management." Neither would workers void of ambition to better their condition or that of their dependents.

Those that have not studied logic are often given to the habit of criticising qualified generalizations that are expressed in unqualified form. They frequently imagine that they have proved a thoughtful man to have been thoughtless, if only they can show that he did not verbally qualify a self-evidently qualified generalization. Such critics would do well to ponder the fact that nearly every generalization expressing a recurrent relationship is qualified in fact even though unqualified in form. "All ice melts"—but only when its temperature rises above 32° F. and when the pressure upon it is within certain limits.

Expressed differently, although a mental generalization is true, it applies only under certain conditions, all of which conditions may not be stated in a verbal generalization.

Principles and Laws.—A scientific principle is a widely applicable generalization arrived at by systematic analysis. Merely to be "widely applicable" does not entitle a generalization to be called a principle. Thus, that wood floats on water is a widely applicable generalization, but it would not be called a scientific principle. On the other hand, it is a scientific principle that a floating body displaces a volume of water whose weight equals that of the body. Systematic investigation was required to discover this latter generalization.

Axioms are occasionally called "basic principles," but it seems preferable to class axioms among self-evident generalizations that are repeatedly used in deductive reasoning. There are thousands of self-evident generalizations that are not axioms, such as "Snow is white," "Wood floats," "Wood is combustible," but these are not repeatedly used in deductive reasoning.

Scientific law (natural law, or law of nature) is a term that is not susceptible of precise definition, except possibly by agreement. Principle and law are usually used as perfect synonyms, but there is a noticeable tendency to restrict the word law to principles in which definite quantitative relationships are stated. Of the 80 laws listed in Funk and Wagnall's dictionary under Law, half are quantitative principles, and about 70 per cent of the 80 relate to physical and chemical principles.

Breadth of Generalizations.—A class is "broad" in proportion to its simplicity; that is, the fewer the interacting forces or elements the broader the class. But the broader the class the greater the number of individual instances in which its members occur.

Motion is a very broad class of thing, of which heat is a narrower class.

A generalization contains at least two classes. How, then, is it possible to compare the relative breadth of two different generalizations? No such comparison can be made, save with respect to one of the pair of classes. Thus, "All animals inhale oxygen" is broader than "All mammals inhale oxygen," and still broader than "All cows inhale oxygen"; because in the class-tree of which "animals" is the trunk, "mammals" is one of the limbs, and "cow" is one of the branches of that limb.

But if we have two generalizations that do not contain members of a common class-tree, then no comparison as to relative breadth of generalization is possible. Thus, "All animals inhale oxygen" and "All plants inhale carbon dioxide" are two incomparable generalizations. Since carbon dioxide and oxygen may be regarded as members of a chemical class-tree, it may at first seem feasible to compare them as to relative "breadth," and thus compare the breadth of the two generalizations under consideration. But the molecule of carbon dioxide, although more complex than the atom of oxygen, does not have the class "marks" of oxygen plus one or more of its own but has only its own "marks." On the other hand, a mammal has all the "marks" of an animal plus some of its own; therefore mammal is a more complex or narrower class than animal.

The Relative Value of Generalizations.—Many futile attempts are made to compare incomparables, and many erronious conclusions occur as a result of the belief that a real comparison has been made. Thus, it is often said that Shakespeare is the greatest genius the world has produced. But what measure can be applied to his poetry that can also be applied to Newton's mathematics?

Educators have frequently said that knowledge of "general principles" (meaning broad principles, for all principles are general) is of greater value to a student than knowledge of "details." Under "details" are included narrow principles. In addition to the fact that there is no definite distinction between broad and narrow, there is a greater objection to the sweeping generalization that broad principles are of more value than narrow principles. As we have seen, a principle that applies to one class of things may not apply to another class. Hence a man working in one field (that is, with certain classes of things) may find that a very narrow principle that is applicable in that field is worth far more to him than is a very broad principle that he can not apply in his specialty. Principles that are of great value to Edison may be of no value to Burbank. Even in a specialist's own field, the value to him of principles or laws does not always depend upon their breadth. In fact a very narrow principle cleverly utilized may yield fortune or fame. We should cease our worship of broad principles merely because they are broad, for a principle is valuable only as it is applied.

If other things were equal (which they seldom are) broad principles would always be much more frequently applied than narrow principles. Then if frequency of use were a measure of value, the breadth of a principle would determine its value. Unfortunately there is no such simple measure of the relative worth of principles. However, it is a fact that in acquiring knowledge it is usually desirable to learn first the broadest principles that can be comprehended. Starting thus with broader (= simpler) classes of things, the student is able more readily to understand the narrower (= more complex) classes, or subclasses.

In learning any subject, whether it be from teachers or unaided, it is usually well to begin with the simplest and progress toward the more complex, which is equivalent to saying that an understanding of the broadest principles should usually be sought first. Failure to follow this rule accounts for much of the erroneous reasoning of political economists, for they have usually begun their study of economics in its most complex form. Instead of first learning the principles of business and engineering economics, they have tried to formulate the more complex principles of social economics.

Even so sagacious a man as Herbert Spencer has erroneously said: "An analysis conducted in a systematic manner must begin with the most complex phenomena of the series to be analyzed." Usually he did not follow this rule, but in the most conspicuous instance of its application by him he arrived at an incorrect explanation of the processes of deduction and induction (see his Psychology, Vol. 2, pages 4 to 16).

Descartes' Principles.—One of the most original of philosophers and mathematicians was Descartes, the inventor of analytical geometry. In his "Discourse on the Method of Rightly Conducting the Reason and Seeking Truth in Science" (year 1637) he said:

"I found that, as for logic, its syllogisms and the majority of its other precepts are of avail rather in the communication of what we already know than in the investigation of the unknown. . . . Instead of the great number of precepts of which logic is composed, I believed that the four following would prove perfectly sufficient for me, provided I took the firm and unwavering resolution never in a single instance to fail in observing them.

"The first was never to accept anything for true which I did not clearly know to be such; that is to say, carefully to avoid precipitancy and prejudice, and to comprise nothing more in my judgment than what was presented to my mind so clearly and distinctly as to exclude all ground of doubt.

"The second, to divide each of the difficulties under examination into as many parts as possible, and as might be necessary for its adequate solution.

"The third, to conduct my thoughts in such order that, by commencing with objects the simplest and easiest to know, I might ascend by little and little, and, as it were, step by step, to the knowledge of the more complex; assigning in thought a certain order even to those objects which in their own nature do not stand in a relation of antecedence and sequence.

"And the last, in every case to make enumerations so complete, and reviews so general, that I might be assured that nothing was omitted."

These four precepts of Descartes may be given the following names:

1. The Principle of Clear Conception.
2. The Principle of Minute Analysis.
3. The Principle of Progression from Simple to Complex.
4. The Principle of Exhaustive Review.

Every man who aims to systematize his methods of thinking will do well to revert to these four principles frequently and ponder their significance.

It will be noted that Descartes puts first the principle of clear conception. This is equivalent to looking back of all words at the mental pictures that they symbolize. It is really astonishing how rarely this is done. Habituated to use language as a tool for reasoning, we are all of us prone to accept words as being the full equivalent of the mental pictures that they are intended to revive. A systematic thinker will seek the mental picture that each word and each sentence is presumed to indicate. This necessitates careful definition of every term. Otherwise verbal generalizations may fail to correspond with mental generalizations.

Descartes' second precept leads to many generalizations that would otherwise remain unknown.

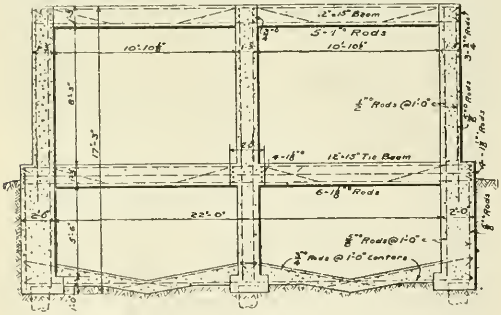
His third precept is often violated, and usually with disastrous consequences. It is self-evident that the greater the number of interacting energies or forces, the greater the difficulty of discovering their effects. But we are often deceived by appearances, and regard as simple what is really very complex. Thus Descartes himself undertook to discover the laws of mental action before much had been learned about the laws of chemistry and physics.

Descartes' fourth precept, thoroughness of enumeration and review of every known subclass, is essential to forming correct generalizations as to the class to which the subclasses belong. Methods of insuring an exhaustive enumeration and review will be discussed in a later article.

Water Filtration Plant Operates on Gravity Supply

The town of Dundas, Ont., has recently placed in commission a 700,000-gal. per day filtration plant which receives its supply through 8,500 ft. of pipe from a new reservoir. The total drop in head to the plant is 200 ft., most of which is consumed in pipe friction.

The filter plant has a number of unique points in its design, a description of which appeared in a recent issue of The Contract Record, from which these notes are taken.



Section of Sedimentation Basin to Show Design of Concrete.

The new filter building adjoins an old reservoir, which has been relined to serve as a filtered water reservoir. As the new building was built on the clay hill, forming the embankment of the reservoir, it was necessary to drive 30 ft. piles to refusal to ensure a safe foundation. These have been placed at 3-ft. centers under all walls.

The sedimentation basin is built two-thirds above the ground in order to obtain the necessary operating head. It is encased in a 9-in. wall, as a protection against frost. An air space between the brick facing and concrete wall, broken up vertically at intervals, stops any air circulation.

The whole design is carried out in reinforced concrete. The sedimentation basin proper, which is 16 ft. deep, 22 ft. wide and 60 ft. long, is divided into two compartments by a longitudinal wall. The reinforcement of these long vertical walls against hydraulic pressure was an interesting problem. Horizontal ties were provided at the top of the basin and at a point about one-third from the bottom, these ties acting as abutments for horizontal beams. The basin wall is thus virtually a vertical continuous beam over three supports and fixed at the lowest one. As cracks are more to be feared than actual failure the basin was designed to resist distortion stresses rather than theoretical stresses due to water pressure.

The long narrow shape of the sedimentation basin is not usually the most economical to construct, but it gives a splendid section for sedimentation purposes. The limitations of the site in this particular case, however, left no option.

Crushed limestone was used as coarse aggregate for the concrete work, with limestone crushings or dust from the crusher for fine aggregate. Sufficient sand was added to give a creamy mortar. The limestone dust was employed partly because of the high cost of sand in the locality and also because of the dense impervious concrete it makes. Density is one of the desirable qualities for this work and the action of lime dust is similar to that of hydrated lime in making concrete waterproof. No water-proofing materials were used.

The filter, which is of the usual type of rapid sand filter, consists of two units, each 11 ft. x 13 ft. 4 in., operating independently and designed for the rate of 1.66 gal. per square foot per minute. Crushed marble in the proportion of 1 to 2, is used in the filter bed. Each unit is provided with a rate-of-flow controller and loss-of-head gage.

An air blower, of 656 cu. ft. per minute capacity, connected directly to the clear water manifold, and an 8-in. centrifugal pump, driven by a 25-HP. motor, comprises the apparatus for back washing the filter. The hand wheels for all valves used in operating the plant, together with the clutch levers from the blower and pump, are grouped together on the operating floor most conveniently for the operator.

As the rate of flow is controlled at the dam, 2 miles from the filter, somewhat unusual methods of handling water at the filter were necessitated. It is admitted to the mixing chamber through a valve controlled by float in the skimming trough. A constant head is thus maintained in the filter beds and any excess water runs to waste.

The two sections of the sedimentation chamber may be operated independently by means of a 10-in. by-pass pipe. This arrangement allows the basin to be cleaned without interrupting the town's supply. Under normal conditions the filter is run at a uniform rate during the 24 hours, the portion in demand being taken care of by the clear water reservoir. The raw water passes through the mixing chamber in about 20 minutes, with a velocity of about 13 ft. per minute and remains 3 hours and 40 minutes in the settling basin, where the flow is about 6 in. per minute.

The cost of the plant was about $30,000. The specifications were made broad enough to permit manufacturers to tender on their own special equipment, but definite enough to ensure uniform tenders.

The works were designed by E. H. Darling, Consulting Engineer, Hamilton, Ont.

Cost of Manufacturing Concrete Pipe

During the past season the Modesto Irrigation District of Stanislaus county, California, constructed several thousand feet of standard concrete pipe. The pipe was hand tamped, reinforced, made in 2 ft. lengths with bell and spigot ends and walls varying in thickness from 1¼ in. for 8 in. to 3 in. for 36-in. pipe. The mix was 1 cement to 3½ sand.

The cost of the pipe was as follows:

Size. In.	Cost per lin. ft.
8	$0.12½
12	.21
16	.36
20	.51
24	.68
30	1.02
36	1.50

The above costs include an allowance of $1,000 for depreciation. Several thousand feet of each size up to and including 24 in. were made. Several hundred feet of the 30-in. and 36-in. pipe also were constructed.

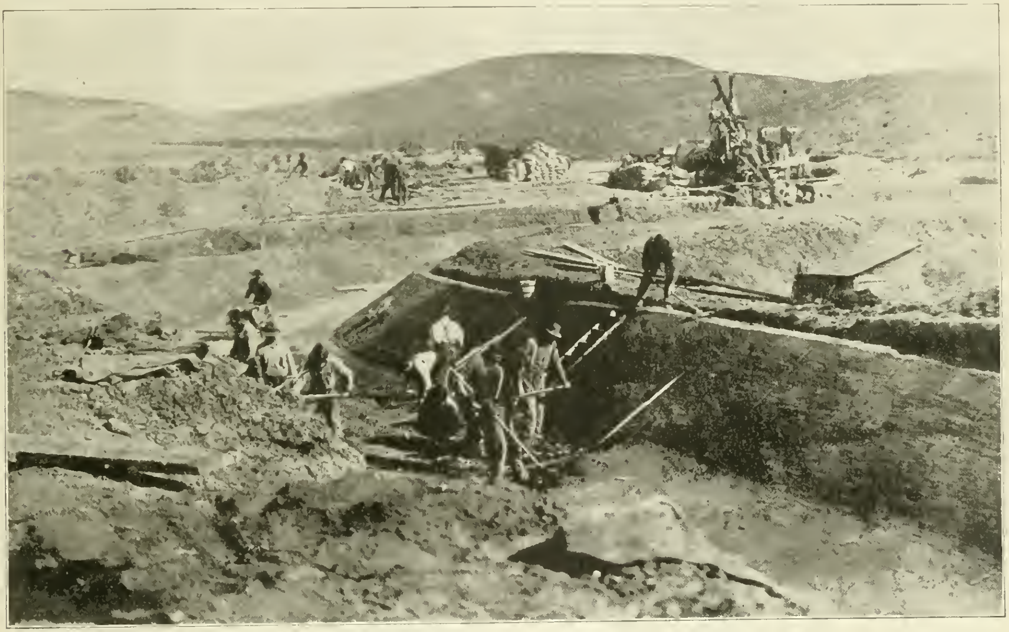
The force consisted of 10 or 12 men at $4 per day each, and a foreman at $5 per day. The cost of materials was:

Cement	$3.25 per bbl.
Sand	1.50 per ton.
Rock	1.50 per ton.

An 8-hour shift was worked, and an average of 350 ft. of 8 in. or 180 ft. of 24 in. pipe was made per shift. P. F. Jones is chief engineer of the district.

Method of Lining Irrigation Canal With Reinforced Concrete

During 1918 the Naches-Selah Irrigation District, comprising 10,500 acres of highly developed orchard land in the Yakima Valley, Washington, lined several thousand feet of irrigation canal with reinforced concrete. This work was done in connection with a scheme for the reconstruction of the system, involving the driving of tunnels and the building of flumes. The plan calls for the construction of 16 tunnels of a total length of 21,000 ft. and the connection of these tunnels by reinforced concrete flumes and by canals lined with reinforced concrete. The tunnel work was described in our issue of Dec. 10, 1919.



Laying Concrete Lining for Irrigation Canal of the Naches-Selah Irrigation District.

The old canal was lined with concrete at the places where the reconstructed canal followed the original location. The old canal was very irregular in shape and the grade in many places was high. The canal section, which was adopted for the most common grade, had a base width of 12 ft., a depth of 4 ft. and side slopes of 1½ to 1. The base was given a dip of 6 in. in the middle and a 4 in tile drain surrounded by gravel was laid under the center, with outlets every 600 ft.

The concrete lining is 3 in. thick, of 1:2:4 mix, and is reinforced with No. 11 electric welded 12 in. by 12 in. mesh wire. The concrete was laid in 5 ft. strips with a screed left to weaken the lining at certain designated points and thus to concentrate the contraction cracks in definite lines.

The concrete was mixed by a batch mixer, mounted on trucks and equipped with side loader, which was located on the upper canal bank, the mixer stations being about 600 ft. apart, varying somewhat with the convenience of locating a sand and gravel dump. At first, the concrete was carried from the discharge hopper to the place of lining by cars hand pushed on track but this method was later supplanted by carts travelling on plank runways. The concrete was dumped in the bottom of the canal on plank shoveling boards and shoveled and partially tamped into place with square pointed shovels. A flight of movable steps was laid on each slope and the material for the upper part of the slopes carried up the steps by laborers with their shovels.

The concrete, after being roughed into place by the backs of the flat shovels, was "floated" by hand and then trowelled into a smooth plane surface by trowels attached to long hoe handles.

The mesh was bought in rolls of sufficient widths to provide two rolls for the bottom and one on both sides. It was simply rolled out down the canal and tied together crossways by means of the projections on the mesh. The mesh was held up from the ground by means of pieces of gravel put under the wire just a short distance ahead of the concrete laying.

A gang of 24 men would do the mixing, hauling and laying for about 150 ft. of canal per 8 hour day. The wages were $4.50 per day most of the time and the per cubic yard cost was $23.16 including steel mesh.

The general construction program and designs for the work were prepared by Elbert M. Chandler, Chief Engineer of Washington State Reclamation Service, who was formerly chief engineer of the irrigation district. We are indebted to Mr. Chandler for the information in this article.

Research Graduate Assistantship at University of Illinois.—To assist in the conduct of engineering research and to extend and strengthen the field of its graduate work in engineering, the University of Illinois maintains 14 research graduate assistantships in the Engineering Experiment Station. Two other such assistantships have been established under the patronage of the Illinois Gas Association. These assistantships, for each of which there is an annual stipend of $500 and freedom from all fees except the matriculation and diploma fees, are open to graduates of approved American and foreign universities and technical schools who are prepared to undertake graduate study in engineering, physics, or applied chemistry. There will be eight vacancies to be filled at the close of the current academic year. Nominations to these positions, accompanied by assignments to special departments of the Engineering Experiment Station, will be made from applications received by the Director of the Station not later than the first day of March.

Low Bacterial Counts at Cincinnati Filter Plant.—Bacteriological data for the filtration plant at Cincinnati, O., for 1918 indicate that the water delivered into service during that year was purer than for any year since the filter plant has been operating. The total number of bacteria averaged only 22 per cubic centimeter, with an average of only 1.99 colon bacilli present in 100 cubic centimeters. These, according to the 1917-18 report of the Water Department, are the lowest yearly bacterial contents on record.

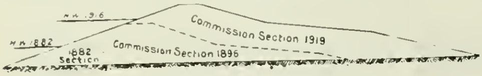
Levee Construction on Mississippi and Its Effect on River Section*

By C. McD. TOWNSEND,

Colonel, Corps of Engineers.

Prior to the Civil War the fronts of the different basins along the lower Mississippi River were protected by lines of levees, though of weak profile and insufficient height. During the war the contending armies frequently cut the levees and the floods of 1862 and 1865 added to the destruction caused by the troops. During the period of reconstruction spasmodic efforts were made by local authorities to repair their levees, but the flood of 1882 again devastated the entire alluvial valley. In 1879 the Mississippi River Commission was organized and the United States began to render assistance to local authorities in reconstructing the levee line. Since 1882 the work has been vigorously prosecuted by the general Government and by state and local authorities.

Sections and Contents of Early Levees.—It is impracticable to determine with accuracy the contents of the levee line prior to 1882. Examinations made by the Commission after the flood indicate that the levees had an average height of between 6 and 7 ft. In the lower Yazoo district their average contents was about 6 yd. per running foot. This amount of earth would construct a levee having a height of about 7 ft., a width of crown of 6 ft., and slopes of 1 on 2, and give a cubic contents to the levee lines of the Yazoo, Tensas, and lower basins of about 33,000,000 cu. yd. In the St. Francis Basin, a levee system could hardly be said to exist, though a few planters had protected their property from river floods.



1882 Section=161 sq ft
Commission Section 1896 = 530 sq ft.
Commission Section 1919=2158 sq.ft.

Fig. 1—Levee Sections.

In 1895 the contents of the levee line were about 100,000,000 cu. yd.

The year 1895 is an important one in the history of levee construction in the Mississippi Valley, marking a change in the policy of the Mississippi River Commission. Prior to that date the Federal Government had confined its efforts to strengthening the existing levees. The St. Francis Basin had remained unprotected, and during floods acted as a reservoir, reducing flood heights, but while protection was thus afforded to the lower valley, the floods of 1890, '92 and '93 were most disastrous to the residents of the 6,000 square miles which formed that basin. Levee districts were then organized, the people raised large sums by taxation and the issue of bonds, the Commission offered similar assistance to that which it gave to other basins, and since that date a substantial levee line has been constructed along the St. Francis front which will afford adequate protection when work which is now under contract has been completed.

In 1913 the levees of the Mississippi Valley contained about 251,000,000 cu. yd., in 1919 about 349,000,000 and it is estimated that it will require about 124,000,000 cu. yd. to complete them to the grade and dimensions adopted by the Commission.

On the ordinary mind only a vague impression of the work that has been accomplished is created by such figures. In Fig. 1 I have graphically presented the same facts, selecting the section of the river at Lake Providence where levee construction has had the maximum effect on flood heights. Opposite Lake Providence the levee of 1882 had an average height of about 7 ft. and contained about 6 cu. yd. per running foot, while the completed levee will have an average height of 22 ft. and contain about 80 cu. yd. per running foot. The increase in flood height from 1882 to 1916 has been 10.4 ft., but the original levee was not equal in height to that of the flood of 1882 while the completed levee will exceed by over 3 ft. the height of the flood of 1916.

The Present Levee Section.—It will be noted from Fig. 1 that the form finally adopted for the levee section differs materially from that which obtains in reservoirs. This arises from the impracticability of finding in an alluvial valley a foundation impervious to water, an essential condition in reservoir construction. The material for constructing a puddle core is also not readily obtainable, nor is such a core of great value when the structure rests on a permeable soil.

The essential conditions of levee construction are a mound of earth of sufficient height so that water can not flow over its top; of sufficient mass, so that surfaces of saturation can not be formed through it on which the superincumbent material will slide; of sufficient width of base, so that the water flowing through the permeable foundation will not have sufficient force to remove any material, it being assumed that the earth has been placed with care, so that there are no channels left across the embankment through which the water can directly flow. This mound of earth must be protected from the eroding action of rains, and its river surface from erosion by river currents and waves during floods. The grade must be somewhat higher than the highest flood to afford protection against wave action during storms.

With the extreme variations in permeability which are found in the soils of which levees are constructed, variations in form become necessary, but practical experience with the soils of the Mississippi bottoms has developed certain forms which are of general application to its levees. A slope of 1 on 3, when well sodded with Bermuda grass, has been found to resist the action of rain, of river currents and of minor waves. In localities exposed to the full force of waves through long reaches of river, it is necessary either to reinforce the sod with some more permanent form of revetment, or to adopt a gentler slope. In the Upper Yazoo District concrete has been extensively used for this purpose.

A width of crown varying from 6 to 10 ft. generally exists. The width to be given to the crown is interdependent with the slope to be given the land side of the levee. An 8-ft. crown affords convenient space for patrolling the levee line during floods, and storing such material as may be required to repair any damage which may be inflicted by storms. With a width of crown of 8 ft., a land slope of 1 on 2 can be safely employed until the levee attains a height of 6 ft.; with higher levees, unless the soil is especially adapted to levee construction, there is a tendency to form surfaces of saturation through the mass on which the upper portion is liable to slide. Levees not exceeding 12 ft. require a land slope of 1 on 3; if of greater heights trouble begins to be experienced with the foundation and still gentler slopes are necessary, or the same results may be attained by adding to the base a mound of earth termed a banquette, which is generally constructed of a width varying from 20 to 40 ft., dependent on the height of levee.

While these levee sections have resulted from practical experience rather than from theoretical considerations, it may be noted that the sections most generally employed in recent years insure an angle of repose of dry earth on wet clay of 14° when water is at the top of the levee, the limiting angle for such materials. When compared with European practice, it will be found that European levees have in general a greater width of crown and steeper land slopes than are found in Mississippi levees, but about the same width of base, but it should be noted that European levees are frequently used as roads.

Length of Levee Line and Area Protected.—In 1882 a continuous levee line did not exist in any district, due to the crevasses which had occurred. Its length can be roughly estimated at about 1,000 miles. In 1913 its length was 1,494 miles, and in 1919, 1,680 miles. The increase in mileage between 1913 and 1919 was principally due to the extension of the jurisdiction of the Mississippi River Commission to the levees of the Upper Mississippi River between Rock Island and Cairo, and those of the Arkansas River, which protect the head of the Tensas Basin.

The area of the basins protected by these levees is 27,116 square miles, but at the lower ends of several of the basins, the lands are subject to overflow by backwater flowing around the ends of the levee systems. The amount of land thus inundated varies with the height of the flood; in 1916 the area thus flooded was reported as being 2,566 square miles. On the east bank of the lower river there are several small basins having a total area of about 710 square miles, which have not been protected by levees, and the sinuosity of the river creates numerous necks of land which it is also unprofitable to protect. In 1913 the estimated area between levees and that overflowed by backwater at the outlets of the various basins was 6,756 square miles, the total area of the alluvial basins of the lower Mississippi being 29,790 square miles.

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*An address presented Nov. 12 before the National Drainage Congress.

The levee line has now attained such dimensions as to afford reasonable security against all but the greatest floods, and offers a fighting chance of success even with such floods as those of 1912 and 1913. "Eternal vigilance" is necessary with any levee system, as a muskrat or other burrowing animal can cause the destruction of the best embankment, if the damage done is not promptly repaired. It may be of interest to note that even during the flood of 1912, 10,814 square miles of the alluvial valley were protected from overflow, by the levee system; in 1913, 19,488 square miles; in 1916, although from Sunflower Landing to Natchez, a distance of 348 miles, the river rose to the greatest heights on record, only one crevasse occurred in the levee line along the Mississippi River, which flooded an area of 818 square miles. Breaks, however, occurred in the levee line along the Arkansas River, which inundated about 2,250 square miles of the Upper Tensas Basin by flowing around the head of the Mississippi levee system of that basin. These levees have recently been placed under the jurisdiction of the Mississippi River Commission. The total area of land protected from overfloow in 1916 was 21,131 square miles.

Effect of Levee System on River Section. There has been considerable discussion of the effect of the levee system upon the river section. It is evident that it has largely increased flood heights, but some contend that the resultant increase in discharge will enlarge the river section so that these extreme flood heights will ultimately be reduced, while others maintain that they have to a large extent been caused by a fill in the river bed.

To one who has not given the matter much thought, it would appear to be an easy matter to solve such a problem by simply comparing river surveys made before levee construction was undertaken with those made at some subsequent date.

The difficulty in utilizing such a comparison is that large changes occur in the river bed from other causes, and it is difficult to differentiate the source of the changes. On a rising river the crossings fill and the pools scour. As the river falls, the reverse action takes place, so that the stage at which the survey is made has a marked influence on the area of the river cross section. There is a marked tencey for sand waves to move along the river bed, which cause large variations in the river section even in one day. If short stretches of the river are compared where a crossing exists in one survey, a pool may be found in the other, and vice versa, so that a comparison of surveys will show a fill or scour, which is due to a local movement of the river trunk downstream. To arrive at any proper conclusion it is therefore necessary to consider average conditions over long reaches of a river.

In 1894 the Mississippi River was resurveyed from the mouth of the Arkansas River to Vicksburg, a distance of about 206 miles. A comparison with former surveys shows that the channel capacity through this reach in 1894 was greater than in 1881-82, due largely to changes above the low water line, that the depths on crossings in 1894 were on the whole greater than in 1881-82, while the greatest depth of pools was generally less; that the high water bars lying between the medium and bank full stage had been cut down an average of something over 1 ft., and that the general tendency seemed to be toward a channel more uniform in depth and of greater capacity.

In 1902 and 1904 surveys were made of the river from Cairo to the mouth of the Arkansas River, a distance of 393.4 miles. When compared with former surveys, it was found that at low stages the average maximum depth had increased for 209 miles, the average mean depth for 200.6 miles, the average width for 222.5 miles, and the average area for 218 miles. The increase in average maximum depth at low water was 1.1 ft. or 3.0 per cent, in average mean depth 0.1 ft. or 0.5 per cent, in average width 128 ft. or 4.7 per cent, and in average area 2,922 sq. ft. or 6.1 per cent. These results are shown graphically in Fig. 2.

The probable errors in observation are, however, greater than the changes observed, so that such results confirm neither theory, but suggest that if any change is taking place in the river bed considered as a whole, it is so small as to be of no practical moment.

European Experiences on Effect of Levees in Raising River Beds.—Those who advocate the theory that levee construction raises the river bed, usually give as an illustration the river Po, and quote as authority a former edition of the Encyclopedia Britannica. This statement appears to have originated in Prony's "Recherches sur le system hydraulic de l'Italia," and was adopted by Cuvier in his "Discours sur les revolution de la surface du globe," who added that the floods of the Po exceeded in height the roofs of the houses of Ferrera; that the Adige and Po were already more elevated than the surrounding territory; and that only by the opening of new beds on the lower part of the land which was formed by their ancient deposits, could the disasters be averted with which the people were threatened. These statements have been repeated in recent works on geology and geography by writers more noted as compilers than as investigators.

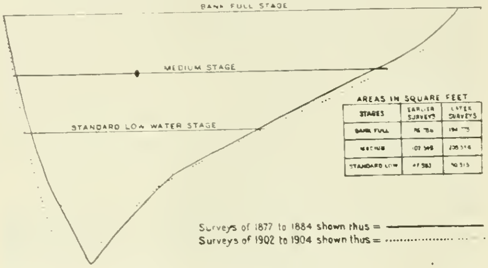

Fig. 2—Mean Sections of Mississippi River From Mouth of Ohio River to Mouth of Arkansas River.

I have frequently invited attention to papers by the Italian Engineer Lombardini in which he refutes the statement, and to investigations by French, German and Austrian engineers, who arrive at the conclusion that the effect of levees in raising the river bed in no case is more than a few inches in a hundred years, and may be termed a geological effect resulting from the lengthening of the river as it deposits its silt at its mouth.

There have recently been brought to my attention two reports on the river Po which exhaustively discuss the same subject. A report of 1905 of a board appointed by the Italian Government and an Extract from the Proceedings of the Italian Society for the Progress of Science (Geneva, Oct. 1912), consisting of a paper by G. Fantoli, "Il Po nelle effemeridi di un Secolo."

The board summarizes the various theories that have been presented as to the effect on the Po of deforestation, drainage, irrigation and levee construction, and the arguments that have been advanced in their support, and arrives at the following conclusions; that the sections in which it is possible to establish a comparison are too few to be able to arrive at a general conclusion Besides there is reflected the great mobility by which the river carves out notable changes in its bed even in the same section in short intervals of time, so that at the same spot there alternate concavities and convexities, pools and bars.

It should not surprise us therefore if the hydraulics of the past century could not find the explanation of that which perhaps only a long observation of many other centuries can solve. Neither should we be astonished if the most illustrious among hydraulic engineers drawn by the heat of discussion in which the minds of the most serene are impassioned, too often arrive at conclusions opposite and contradictory by being compelled to demonstrate that which does not exist. They state there is some evidence to substantiate the theory of Boucker that periods of drought alternate with those of excessive rain in a complete cycle of 34 to 35 years, obscuring an analysis of gage records of 10-year means, and conclude with the statement that the impression is confirmed that the problem is not yet solved, and that it would be logical to leave the solution to posterity, reserving to ourselves the modest but profitable task of collecting and arranging the data so that they may be transmitted to our sons in such a manner that a day will arrive when it will be possible to pronounce a correct judgment on questions so much in controversy and today still unsolvable.

Prof. Fantoli does not consider it necessary to leave the solution of the problem to posterity. While he agrees with Lombardini that with the data available in 1844 a Scotch verdict of not proven was justifiable, he is of the opinion that the gage records of 100 years, particularly those at Pontelagoscura, recently published, afford sufficient data for its solution. It is to be noted also that Pontelagoscura is in the vicinity of Ferrera, the locality mentioned by Cuvier as requiring such drastic action.

In his analysis of the gage records he divides the observations into periods of 10 years each, and obtains the mean high, the mean low, and the mean stage for each period, but finds that due to extraneous influences such as irregularity in rainfall, there is an uncertainty as to the nature of the changes. By combining the observations in periods of 20 years these extraneous causes appear to be more completely eliminated. He finally compares the means of the first 40 years of the century with those of the last 40 years, and concludes that if there is a marked change in the 40-year means which is accompanied by progressive changes in the 20-year means, a permanent change in the river regimen is demonstrated.

By this process of reasoning he comes to the conclusion, that at Pontelagoscura flood heights within the last century have been lowered on an average about .8 in., the mean height about 6 in., and low water about 9.2 in.

He also analyses the number of days in a year the water level is between certain gage heights, and finds that the river is below the 4-metre mark below zero on the gage on an average of 22 days more in the last 40 years of the century than in the first 40 years.

Having thus demonstrated that there has been a gradual lowering of the low water plane at Pontelagoscura, he seeks the cause and comes to the conclusion that at least four-fifths of the effect is directly traceable to the increased use of the waters of the Po for irrigation.

From a discussion of measured discharges he discards the idea that any of the lowering of the low-water plane was due to a deepening of the bed of the river, and also expresses the opinion that the effect of deforestation on the river flow is insignificant. He further discusses the relation of run off to rainfall, and while considering that further observations along this line are desirable, can find no evidence of an increase or diminution in the amount of rainfall in the valley as the results of man's works.

The paper is a most exhaustive analysis of the data available in the Po Valley, which affects the river's regimen, and merits much more consideration than can be given in this brief summary.

American Records Confirm Prof. Fantoli's Theories.—Gages are daily read at numerous localities along the Mississippi River from Aitkin, 1,090 miles above Cairo, to Fort Jackson, 1,039 miles below. An analysis of the records of such of these gages as extend over a continuous period of 40 years, similar to that made by Prof. Fantoli of the gages along the Po, develops some rather interesting confirmations of his theories.

At St. Paul, there has been a lowering of mean and extreme flood heights in recent years, but no appreciable effect on low water. This can be attributed to the construction of reservoirs at the head waters of the river. From Lake Pepin to Rock Island, there has been an increase in the low water heights, and no marked reduction in floods. In other words, Lake Pepin had regulated the earlier floods as the reservoirs have modified those of later date. From Rock Island to Hannibal there is little change in high or low water conditions. At Grafton there is marked increase in the height of low water in recent years due to the flow of the Chicago drainage canal. At St. Louis there is a marked lowering of the low water plane, which disappears at Grays Point, and is due to the river improvements at the former locality. At Cairo mean flood heights have increased less than a foot, while the low water plane appears to have risen about 2 ft. A similar raise of the low water plane is observable at the mouth of the White River and of the Red River, and at Natchez, and is negligible at other localities.

At Cairo and at the mouths of the White and Red Rivers, the levee system has not been completed, and if it be assumed that the increase in the height of low water in recent years has been due to a raising of the river bed, it follows that the rise in river bed is inversely proportional to the construction of levees, being least where levee construction is the most advanced. If it be assumed that the increased heights of low water in recent years at Cairo is due to an increased discharge in the same period, the conclusion will be that in the middle of the basins where the levee system is most effective there has been a slight enlargement of the river section, as indicated in Fig. 2. The uncertainty as to whether Cairo is a proper origin of comparison for phenomena on the lower river emphasizes the contention of Fantoli that observations should extend over a century before positive conclusions can be deduced.

It can, however, be asserted that these records afford no evidence of a material change in the regimen of the river from levee construction.

Malaria Control As a Business Investment

That malaria can be controlled has been demonstrated frequently, but work on a large scale has been hampered by lack of funds or the employment of uneconomical methods. Recently, however, considerably work has been done in the Southern States at a moderate cost. An account of this work is given in an article by Dr. Wickliffe Rose, general director of the International Health Board, in a recent issue of The Journal of the American Medical Association.

Crossett, Ark., a lumber town with a population of about 2,000, is an example and the work done there is typical. A survey of the community was first made to locate the breeding places of the mosquitoes. All effort was then centered on the eradication or control of such places. Ponds were drained, streams were cleared of undergrowth, artificial containers were removed, water barrels on bridges were treated with niter cakes, while certain other ponds or streams were sprayed with road oil once a week. As a result of these and other measures, there was a reduction in malaria of 72.33 per cent and the per capita cost, omitting overhead, was $1.24.

Another village, Lake Village, Ark., was used as an experiment for the eradication of malaria by screening the homes. The work was conducted in cotton plantation cabins which were difficult to protect. All selected houses were screened with galvanized wire cloth, 16 mesh, and the inhabitants were taught by house-to-house visits the importance of keeping the screens in good condition. An index taken in May, 1916, when the work began, showed an infection of 11.97 per cent; a second index taken in December of the same year showed an infection of 3.52 per cent, a reduction of 70.6 per cent. The average cost of screening the community was $14.59 per house or, with a 2-year life for the screens, an annual cost of $1.75 per capita.

Another method employed was to give sterilizing treatment to persons in a community who had a history of clinical malaria during the past 12 months. Ten grains a day for eight weeks were prescribed and repeated house-to-house visits were made to see that the treatment was regular. One plantation area under control had a population of about 600, while another not under control had a population of about 180. The results of the treatment showed that in the smaller uncontrolled area the doctor's bill for the year was greater than in the larger area.

Dr. Rose's conclusion is that malaria control is a sound business investment. He advocates making a demonstration at some point within each malarial region, after which there is usually no difficulty in getting the community to tax itself for carrying on the work on a larger scale.

Saving Labor in Handling Meter Records.—Refolioing the records of the Meter Department of the waterworks of Cincinnati, O., so as to correspond in their rotation with the order in which the meters are read by the reader, not only eliminated two men's work 17 days monthly in rearranging these cards, but also has reduced the time formerly consumed by meter readers to such an extent that within one year's time one whole week was gained in meter reading.

Some Results of the Brooklyn, N. Y. Sewage Treatment Experiments

The results obtained from five years' operation of an experimental sewage treatment plant on the 26th Ward Sewer in Brooklyn, N. Y., were presented in a paper before the recent annual convention of the American Society for Municipal Improvements by Mr. George T. Hammond, U. S. Public Health Service, Consulting Engineer, Brooklyn, N. Y. The paper is full of interesting data pertaining to Imhoff tank operation, trickling filters, etc., although the data obtained on the activated sludge treatment are withheld at the present time. The following notes from this paper are necessarily quite general.

The experimental plant included three Imhoff tanks of different depths, but with other corresponding dimensions equal; six trickling filter beds, two of which were designed for discharging compressed air within the mass of the stone medium; various tanks and apparatus for the investigation of sewage treatment by forced aeration; secondary settling tanks for the trickling filters, and for the sewage treated by aeration; a plain settling tank for crude sewage in connection with an airtight sludge digestion tank, which received the settled matters and sludge from the settling tank, being in effect the two essential portions of an Imhoff tank separated; 10 sludge-drying beds, and various units for experimenting with fine-screening sewage, and for drying sludge.

Mechanical equipment such as pumps, air compressors, devices for measuring the air, and other necessary equipment was also provided.

The sewage treated was from the 26th ward in the Borough of Brooklyn and the contributing population was estimated at about 220,000. The dry weather flow in the main sewer was at the rate of from 18,000,000 to 27,000,000 gal. per day. The experimental plant treated 1,200,000 gal. per day and the average content upon which the report is based was: suspended solids—total, 168; volatile, 129; non-volatile, 39; biochemical oxygen demand, 223, all results being in parts per million.

The average nitrogen contents of sewage were as follows:

Free ammonia	32.00 p.p.m.
Organic nitrogen:	
Total	27.00 p.p.m.
Dissolved	18.00 p.p.m.
Nitrites	0.26 p.p.m.
Nitrates	0.00 p.p.m.

One of the notable features of the local sewage is the proportion of colloidal suspensa in very finely divided condition, which settles very slowly if at all. The different tanks removed a satisfactory percentage of settleable solids, but to a large extent this non-settleable material remained in the sewage.

The station was provided with three Imhoff tanks of the following dimensions:

Diameter of tank, ft.	15.00	15.00	15.00
Depth, total, ft.	30.38	21.88	13.67
Width of settling chamber, ft.	10.67	10.67	10.67
Depth of settling chamber to slots, ft.	13.97	10.05	7.00
Depth of settling chamber to slopes, ft.	9.22	5.30	2.42
Slopes inclined from level, degs.	41° 43′	41° 43′	41° 43′
Depth of scum boards, ft.	1.54	1.54	1.54
Depth of baffles, ft.	9.50	7.79	5.54
Capacity below w. l., cu. ft.	1,610.00	1,113.00	557.00
Capacity below w. l., gal.	12,050.00	8,325.00	4,166.00
Capacity 1 hr. retention, gal.	290,000.00	200,000.00	100,000.00
Capacity 2 hr. retention, gal.	145,000.00	100,000.00	50,000.00
Digesting chamber diameter, ft.	15.00	15.00	15.00
Digesting chamber depth, ft.	16.42	11.83	6.67
Capacity below slot-line, cu. ft.	2,128.00	1,317.00	469.00

The gas vents, being segments of the 15-ft. diameter circle, cut off by the walls of the flowing-through chambers, were 2 ft. wide at their greatest width. They were at all times ample for the purpose.

The tanks were completed and put in service Oct. 1, 1913, and a few days later, at the suggestion of Dr. Rudolph Hering, ripe sludge was obtained from the tanks of the Pennypack Creek sewage disposal plant near Philadelphia, and with this each tank was seeded. The ripening period extended through the severe winter of 1913-1914 and was not completed in either of the tanks until May 21, 1914, when No. 2 and No. 3 gave ripe sludge, but No. 1 did not ripen until June 11. The tanks, however, all continued to improve in operation during the year 1914. Early in the spring there was considerable smell from all of them, but this disappeared during the summer, and did not return until the following spring. Improvement continued throughout the entire period of operation, and the tanks were doing their best when finally shut down in 1918. At no time during the experiments was there any evidence of sludge accumulating on the slopes of the settling chambers. The slopes inclined only 41 degrees 43 minutes from level.

The double slot placed at the lowest point, i. e., the intersection of the planes of each side, without permitting the crest of the baffle to emerge into the settling tank and form an obstruction to sliding matters—was of much importance in keeping the slopes clean. The settlings do not appear to go through the slot at the foot of the slope down which they slide, unless they are heavy. The light-weight materials and much of the heavy, appear to jump over this space and go through the other slot, which does not require a change in their direction of movement. It appears from the work of the Brooklyn tanks that the design of slots is far more important in its relation to tank operation than has been generally recognized in practice.

At times during the experiments, and without any apparent reason, the entire body of sludge in the digestion chambers of the different tanks would rise to the top, usually without foaming or frothing, and remain for a day or two, then slowly settle. At such times there was considerable odor present, and when foaming occurred there was a strong and very persistent odor. Churning the scum with a hoe in the gas vents, or breaking it up with a paddle, usually sufficed to release the entrained gas and permit it to settle. A jet from a hose is probably the most effective method of doing this. At no time was the foaming so serious that it could not be controlled, but while it lasted the tank gave forth bad smells, and its efficiency as a remover of suspended matter decreased more than half. The settling chambers were at no time involved in foaming and very seldom showed any scum.

The settling tanks (Dortmund type) never showed the least inclination to foam, and never gave forth odors that could be recognized as coming from sewage a few feet away. This may have been because they were not intended for, or used as digesting or septic tanks, the settling matters and sludge being removed daily for other treatment.

It may be added that the Imhoff tanks very seldom caused odors, and at times when they did, if it was not due to foaming, it was probably due to a septic condition of the sewage entering them. At one time during the experiments all of the tanks caused odors, and it was discovered that the main sewer had become very foul from deposits. After the sewer was cleaned out these odors ceased, and did not occur until the sewer again required cleaning. When this was done, odors again ceased, at least suggesting the connection between bad smells from a disposal plant, and neglect in keeping sewers clean.

Floating scum was but seldom present in the settling chambers, and when present usually consisted mainly of grease which separated out from the sewage matters. The scum boards were quite efficient in preventing floating matters. Such scum and other materials as collected behind the scum boards were paddled from time to time, and settled without much trouble. When necessary, materials that did not settle were thrown into the gas vents.

Floating scum in the gas vents, taking the period from Jan. 1915, to the end of April as representative, was made up as follows:

(Quantities given in per cent of total constituents.)

	Imhoff Tank		
	1 %	2 %	3 %
Moisture	80.2	81.5	84.6
Solids	19.8	18.5	15.4
Mineral	26.0	27.7	30.5
Organic	74.0	72.3	69.5
Fats	26.6	25.4	11.2
Average depth of scum, inches	3.75	1.50	0½

Settling tank 3 (Dortmond type) was 8 ft. x 8 ft. in plan, with a vertical depth of 4 ft. and a hopper bottom, leaving its apex line 3.6, making the greatest total depth 7.6 ft.

The flow entering through pipe was carried down near the center, and discharged into the tank 5 ft. below the water line. The effluent was taken off through 8 V-shaped notches in the sides of the outfall trough, that announces the top on all four sides. A 6-in. sludge discharge pipe was placed in the center, ending with a bell at the bottom, and having a clean-out at the top above the water line. Sludge was discharged from this pipe through a horizontal branch placed about 2 ft. below the water line and, passing through the south wall of the tank, discharged through a gate-valve into the flume leading to the sludge-drying beds, etc.

Before passing through the wall, this horizontal portion of the sludge pipe gave off a branch, consisting of 4-in. pipe controlled by a gate-valve, which passed to a sludge-measuring tank, into which the daily settlings and sludge deposited in the hopper could be discharged and measured, and from which they could be fed slowly by gravity into the sludge digestion tank.

The "digestion tank," or digesting tank, was of steel plate, made to be air and water-tight, 5 ft. in diameter and 15 ft. deep, with a conical bottom. It was set vertically in the ground. Data regarding the settling, digestion and humus tanks are given in the following table:

	Settling Tanks 1-4.	Digestion Tank.	Humus Tanks.
Elev. water line, ft.	7.80	+6.50	6.02
Elev. top. of hopper bottom, ft.	3.80	—1.50	....
Elev. bottom hopper bottom, ft.	0 20	—7.00	—3.90
Depth below w. l., ft.	7.60	13.50	9.92
Size water surface, ft.	8x8	D.5.00	5.6x5.6
Capacity, cu. ft.	285 00	265.00	127.00
Capacity, gal.	2.132 00	1,988.00	950.00
Capacity 1 hr. retention, gal.	51,168 00	....	22,800.00
Capacity 2 hr. retention, gal.	25,584 00	....	11.400.00

Sludge ripened in this tank perfectly, and could not have been distinguished from Imhoff-tank ripe sludge. It was full of gas bubbles and dried readily on sludge beds.

The operating depth of the tank was 13.5 ft. The net cubic capacity for digesting sludge was 265 cu. ft.

Settling tank 3 had a net capacity of 285 cu. ft., and working at a theoretical 2-hours' retention treated 25,584 gal. of sewage per day, equal to sewage of 250 people, the digestion tank thus affording only a space of 1,060 cu. ft. per capita, which with this arrangement of tank appeared to be sufficient for producing a good, ripe sludge.

Ripening of sludge in the separate digestion tank was much more rapid than in the Imhoff tanks. On being started the tank was seeded with a few gallons of ripe Imhoff sludge, which may have helped. Operation began late in March, and on July 27, four months after starting, 26 cu. ft. of ripe sludge was withdrawn. On Sept. 17 all the ripe sludge was withdrawn, and no further sludge added for digesting, for several months. During this period it produced in ripe sludge up to the time of the shut-off, 78 cu. ft., and later the unripe sludge remaining after the shut-down digested completely, giving 20 cu. ft. more, in all 98 cu. ft. The ripe sludge contained before drying 94 per cent moisture and dried to 64 per cent moisture; it averaged about 37 per cent volatile, as compared with the Imhoff sludge which averages more than 45 per cent volatile.

The sludge in the three Imhoff tanks had, on the average, the following solid content: Tank 1, 8.9 per cent; Tank 2, 8.9 per cent; Tank 3, 6.7 per cent. As related to the sludge-storage capacity, it will be noted that the volume occupied by any particular weight of dry solids in sludge is inversely in proportion to the percentage of solids, so that the per capita yield of dry solids in Tank 3 will occupy a volume, 8.9 divided by 6, equal to 1.3 times the volume occupied by the per capita yield in the other two tanks. Thus if 1.33 cu. ft. per capita be the allowance for a tank 20 ft. deep, 1.73 would have to be allowed for one 14 ft. deep, owing to the greater water content of the sludge.

This may be studied in a slightly different manner. If the average solid content be obtained as the result of combining individual figures weighted with the amount of sludge at the particular draft, the solid contents are as follows: Tank 1, 8.8 per cent; Tank 2, 7.5 per cent; Tank 3, 5.6 per cent. Calculating the volumes as above, a per capita sludge-chamber allowance of 1.33 cu. ft. in a 20-ft. tank would be equivalent to 1.12 cu. ft. in a 30-ft. tank, and to 1.86 cu. ft. in a 14-ft. tank.

The required area of sludge-drying beds should not be less than ⅓ sq. ft. per capita. The best medium for the sludge drying beds was found to be steam ashes, a sand covering being if not undesirable, at least unnecessary. The depths of wet sludge did not exceed 9 in.

The digestion, storage, and drying of sludge was at no time accompanied by nuisance. The shrinkage in volume occurring during the first day of drying amounted to about 60 per cent. The period of drying was 1 to 7 days in good weather. In stormy weather it amounted to from 10 to 14 days. When ready for removal from the bed, the dry sludge was friable and porous, and occupied a volume not exceeding 25 per cent of its volume before drying. When deposited on the dump, still further shrinkage occurred.

In studying tank performance and the results of these observations on the required capacity of digestion chambers, the conclusion was that the space per capita as determined would be too small for general use in the design of tanks for disposal plants to be operated in the ordinary manner, and that it should be made larger to avoid the danger of foaming. The larger the digestion chamber, the less danger of this appeared to exist in these tanks. Therefore, as a factor of safety it was concluded that 50 per cent should be added to the figures obtained, when used for purposes of design, giving 2 cu. ft. per capita for a tank 20 ft. deep.

Removals Effected by Tanks, 1914-1915.

	Imhoff Tanks 1	Imhoff Tanks 2	Imhoff Tanks 3	Settling Tank 3.
Per cent of reduction effected	%	%	%	%
Volumetric:				
Solids settleable in Imhoff cone	62	64	78	80
Gravimetric:				
Total suspended solids	27	27	40	40
Total settleable solids	53	62	66	61
Total colloidal solids	26	12	21	21
Total volatile solids	31	31	46	40
Oxygen demand	29	34	41	20
Retention in tanks, hr.	2	2	2	2

Summary of Sludge Drying Data.

	Imhoff Tanks 1	Imhoff Tanks 2	Imhoff Tanks 3	Separate Dig. Tank.
	%	%	%	%
Moisture before drying	91.1	91.1	93.3	94.6
Moisture after drying	67.8	66.2	69.7	64.1
Volatile solids	45 5	46.5	46.7	36.6
Average depth on beds, inches	9.0	9.0	9.0	10.0
Average number of days drying	7.1	7.3	7.1	7.3

The fine screens from which the data following were obtained are two in number, of the Reinsch-Wurl design, installed at the 26th ward treatment plant as a permanent part of that plant. They were completed and commenced operation early in 1916 and since then have been in service.

Until 1917 the two screens, the north and south, had 5/64 and 1/16 in. slits, respectively.

For the north screen during this period the following data was obtained: Sewage screened, 3 08 million gal. per 24 hours, average loss of head, 0.118 in. suspended solids removed, 14 per cent. For the south screen, the average quantity was 8.2 million gallon per 24 hours, loss of head, 121 in., suspended solids removed, 18 per cent.

There were two groups of trickling filter beds which have been indicated as Group A and Group B.

Group A consisted of the ordinary type of trickling filters. There were four beds. Each bed was square and had an effective area of .004 of an acre. Partitions, 4 in. thick, were carried from the floor to the surface of the medium between adjacent beds.

The outer walls of the beds were formed by means of reinforced concrete piers, carrying a slab coping of reinforced concrete at the tip. The piers were cast with slots for receiving 3-in. yellow-pine slabs or shutters, which were set at an angle of 45°, sloping inward, spaced 2 ft. apart, against which the medium rested, affording a maximum admission for air and preventing the escape of sewage.

The medium was 10 ft. in depth over the top of the underdrains, and of very carefully selected broken trap-rock, many runs through screens having been necessary to obtain the result required.

Group B was a tank 12 ft. in diameter and 16 ft. high in which were placed two beds. A partition wall divided the tank into two equal parts and each side was filled with stone filtering medium to the same depths. The bottom of each side was under-drained with 6-in. half-pipe tile, on a concrete bed, and closed from external air by the tank walls. Each side was kept entirely from the other, and drained independently to a secondary tank. Each side was provided with a grid for supplying compressed air, placed within the medium near the bottom, formed of ¾-in. iron pipe, perforated every 6 in. with ⅛-in. holes, through which compressed air could be supplied. The area of each bed was .00127 acre.

Trickling filter No. 3, which is typical, showed the following average results for 3 summer months: Suspended solids 59, dissolved oxygen 4.7, relative stability 100 per cent, oxygen demand 35, all in parts per million. The daily rate of application was 4 mil. gal. per acre.

Final settling tanks proved to be essential in the treatment of the effluent from the trickling filters. The sludge settled out in the settling tanks at times made all the difference between a putrescible and a non-putrescible effluent from the plant. This sludge was highly putrescible and very difficult to dry. It should be returned as a rule to primary tanks for full treatment.

The quantity of settlings removed by these tanks seemed to be about the same whether the sewage had passed on Imhoff tank or a fine screen before filtration, and to depend mostly if not altogether on filter conditions and phenomena.

The settling tank following filter No. 3 removed in 1 hour's retention, from Oct., 1914, to Sept., 1915, 62 per cent of the solids in suspension in the filter effluent. The settling tank following filter No. 1, removed in 2 hours' retention 90 per cent of the solids, and the settling tank following filter No. 5 removed in 3 hours' retention 70 per cent of the effluent suspensa. With these tanks in operation bacterial removal approximated 99 per cent and the plant effluent was 100 per cent stable.

Pollution of Deep Wells by Sewage

As a result of sewage contamination of wells due to faulty joints in well casings, the city of Lansing, Mich., suffered a serious epidemic of dysentery and some typhoid. This occurred last March during a season of high water when the sewers operated under a 2½-ft. head. A detailed account of the cause and remedy is given in a paper by Mr. Edward D. Rich, State Sanitary Engineer, Lansing, Mich., presented at the recent annual meeting of the American Public Health Association. The following excerpts are from the paper.

Lansing obtains its municipal supply from 32 wells from 350 to 400 ft. deep terminating in what is known as "Coal Measure" sandstone. There are five separate pumping stations which pump directly into the mains. One of these, known as the Townsend St. Station, obtains its supply through a suction main about 1,000 ft. long. On account of the length of the suction main and the lowering of the ground water level during recent years, it is necessary to maintain a normal vacuum of 22 in. of mercury. This station is located only about 200 ft. from the Grand River. A sewer which passes only 10 or 15 ft. from some of the wells ordinarily has a free outfall, but at times of high water, the sewer is under a pressure at the lower end, thereby discharging polluted water into the surrounding sandy soil. This was the condition that obtained last March during high water. The polluted water found its way into the wells through faulty connections at the top and in a few days there were many cases of dysentery throughout the city. Conservative estimates placed the total number of cases at about 3,000, not including 82 cases of typhoid with 11 deaths, which also accompanied the outbreak. The economic loss was estimated by one motor car company at $40,000.

This pumping station, which was ordinarily shut down at times of high water, was immediately discontinued, and steps were at once taken to chlorinate all of the supply. Subsequent samples from individual wells at this station caused two out of the five wells to be permanently disconnected and plugged. The remaining ones have gradually returned to their normal state of purity.

Water Purification and Typhoid Fever at Cincinnati.—Filtration of the entire water supply of Cincinnati, O., was started on Nov. 7, 1907. The following table, from the recently issued report of the Water Department for 1917-18, shows the effect of this water purification in reducing the number of cases of typhoid fever:

Year.	Cases		Deaths	
	Total.	Rate per 100,000.	Total.	Rate per 100,000.
1900	522	160.0	119	36.5
1901	729	221.5	180	54.7
1902	1,038	312.7	206	62.1
1903	710	211.1	144	42.8
1904	1,646	475.9	270	78.1
1905	746	213.9	155	44.4
1906	1,940	551.6	239	68.0
1907	1,252	352.8	157	44.2
1908	235	65.7	64	17.9
1909	218	60.4	46	12.7
1910	202	55.5	21	5.8
1911	238	62.9	43	11.4
1912	182	48.0	28	7.2
1913	266	66.8	24	6.0
1914	148	36.8	23	5.7
1915	141	34.7	29	7.1
1916	98	23.8	13	3.2
1917	89	21.5	16	3.9
1918	84	20.1	17	4.1

Classification and Compensation of Engineers as Proposed by Engineering Council Committee

A classification for engineers in federal, state, county, municipal and railroad service was approved by Engineering Council at its meeting on Dec. 18, when it adopted the classification proposed in the third progress report of its committee on classification and compensation of engineers, of which Arthur S. Tuttle, M. Am. Soc. C. E., is chairman. Eight grades are defined, five professional and three sub-professional, and the necessary qualifications are specified. A striking comparison of the results of this investigation into federal, state and municipal service with those reported in 1917 by the committee of the American Society of Civil Engineers appointed to investigate the conditions of employment and compensation of civil engineers was pointed out in the committee report.

The extracts of this report which follow include, in addition to the classification and the above-mentioned comparison, an interesting tabulation of average salaries in federal, state and municipal service, with average ages of the incumbents and average salaries recommended by the engineers in charge. The committee asked for an appropriation of $10,000 for the purpose of continuing the investigation into present salaries and to insure publicity and progress in the effort to raise the level of engineering compensation. This is one of the items for which Engineering Council is making appeal for funds.

Findings and Conclusions of the Committee.—The investigations have shown the lack of any adequate or consistent employment policy with respect to professional engineers. This is evidenced by the following conditions which are believed to be largely responsible for the unsatisfactory status of men engaged in this class of work:

1. Absence of any uniform system of grading of positions.
2. Lack of uniformity in titles of positions with respect to duties.
3. Inequalities in compensation for positions of the same grade.
4. Generally inadequate compensation for services rendered.

To the end that these conditions may be corrected and proper and equitable conditions of employment established, the following principles and practices are recommended by the committee, though not yet acted upon by Council.

1. Positions should be classified in accordance with the type of work, and with the character of the duties to be performed and the qualifications necessary for their performance, as indicated by a system of grading.

2. Within the salary limits fixed for each grade, there should be a system of advancement through the grade based upon experience gained in the position and upon proof of increase in the proficiency of the employe in performing the duties of the grade.

3. Promotions from grade to grade should depend upon the existence of a vacancy in the higher grade and proof that the employe is qualified to fill the vacancy.

4. The determination of salary adequate to procure for and retain in engineering work a high class of employees, should take into account and properly weigh the following considerations:

(a) The capital invested, both in money and in time, in obtaining the requisite fundamental training.

(b) The amount and character of experience and the degree of personal ability required.

(c) The relative value of the classes of work to be performed.

(d) The amount paid for similar service in other lines of work.

(e) The amount necessary to enable the employe to maintain a standard of living commensurate with the general standards of the community for positions of similar dignity and responsibility.

5. In the interest of an adequate social policy, no position likely to be occupied by individuals of an age to assume family responsibilities should fail to pay an amount sufficient to permit the maintenance of the average family in reasonable decency and comfort.

6. In the interest of the employes as a whole and of the

employer, a system should be established by which employes who fail to maintain satisfactory standards of service should be removed, transferred, demoted, or retired as may be equitable in the circumstances.

Classification of Engineering Positions in Federal, State, County, Municipal and Railroad Services.—The grades proposed have been divided into two classes, the professional service being deemed to include men who have received an engineering degree from an educational institution of recognizd standing or who have obtained similar qualifications through practice of the profession and by mastering the fundamentals of engineering science, while the sub-professional service includes assistants with at least a high school education, who enter upon the practice of the profession in the performance of responsible duties for which an engineering training is not essential, but who through experience and study may fit themselves for the higher grades. The classification is as follows:

PROFESSIONAL SERVICE.

Grade 1.—Chief Engineer: Duties.—To act in chief administrative charge of a technical organization, or of a main division thereof; to determine the general policies of the organization under the limitations imposed by law, regulation, or other fixed requirement; to have final responsibility for the preparation of reports, cost estimates, designs, and specifications and for the construction, maintenance, or operation of engineering works or projects; to have full charge of the collection and presentation of data for and the conduct of valuation proceedings; to conduct or direct the most comprehensive lines of engineering research.

Qualifications.—Training and experience of a character to give substantial evidence of engineering knowledge and ability or of executive capacity of highest order along lines of work similar to those involved in the position to be occupied and of at least twelve years' duration, of which at least four years shall have been spent in duties of engineer, or their equivalent, and at least five years in responsible charge of important work or projects. Fundamental training equivalent to that represented by professional degree granted upon the completion of a standard course of engineering instruction in an educational institution of recognized standing or, in absence of such degree, at least four years of additional experience. The completion of each full year of such standard course shall be considered the equivalent of one year of such additional experience.

Grade 2.—Engineer: Duties.—Under general administrative direction and within the limits of the general policies of the organization, to have responsible charge of and to initiate and determine policies for a major subdivision of an organization; to prepare for final executive action reports, cost estimates, designs, specifications, and valuation studies and data; to have immediate charge of the construction, maintenance, or operation of engineering works or projects of major importance; to conduct or direct major lines of engineering research; or to furnish for executive action expert or critical advice on engineering works, projects or policies.

Qualifications.—Active professional practice or executive charge of work for at least eight years, of a character to demonstrate a high degree of initiative and of ability in the administration, design, or construction of engineering work or projects of major importance, of which at least three years shall have been spent in duties of senior assistant engineer, or their equivalent, and at least three years in responsible charge of work. Fundamental training equivalent to that represented by professional degree granted upon the completion of a standard course of engineering instruction in an educational institution of recognized standing or in absence of such degree, at least four years of additional experience. The completion of each full year of such standard course shall be considered the equivalent of one year of such additional experience.

Grade 3. Senior Assistant Engineer: Duties.—Under general administrative and technical direction, to be in responsible charge of an intermediate division of an organizathion; to exercise independent engineering judgment and assume responsibility in studies and computations necessary for the preparation of reports, cost estimates, designs, specifications, or valuations; to have immediate charge of the construction, maintenance, or operation of important engineering works or projects; or to conduct or direct important lines of engineering research.

Qualifications.—Active professional practice or executive charge of work for at least five years, of which at least three years shall have been spent in duties of assistant engineer, or their equivalent, with at least one year in responsible charge of work. Fundamental training equivalent to that represented by professional degree granted upon the completion of a standard course of engineering instruction in an educational institution of recognized standing or, in absence of such degree, at least four years' of additional experience. The completion of each full year of such standard course shall be considered the equivalent of one year of such additional experience.

Grade 4.—Assistant Engineer: Duties.—Under specific administrative and technical direction, to be responsible for the conduct of the work of a minor subdivision of an organization; to collect and compile data for specific items of engineering studies; to take immediate charge of field survey projects and of the design and construction of minor engineering work; to lay out and develop work from specifications and to supervise the work of a drafting or computing force; or to conduct specific tests or investigations of apparatus, material, or processes.

Qualifications.—Experience for at least two years in duties of junior assistant engineer or their equivalent. Fundamental training equivalent to that represented by professional degree granted upon the completion of a standard course of engineering instruction in an educational institution of recognized standing or, in absence of such degree, at least four years of additional experience. The completion of each full year of such standard course shall be considered the equivalent of one year of such additional experience

Grade 5.—Junior Assistant Engineer. Duties.—Under immediate supervision, to perform work involving the use of surveying, measuring, and drafting instruments; to take charge of parties on survey or construction work; to design details from sketches or specifications; to compute and compile data for reports or records; to inspect or investigate minor details of engineering work; or to perform routine tests of apparatus, material, or processes.

Qualifications.—No experience required other than that involved in securing a professional degree upon the completion of a standard course of engineering instruction in an educational institution of recognized standing; but in absence of such degree, a high school education or its quivalent is required and at least four years' experience in the use of surveying, measuring or drafting instruments, or the computation and compilation of engineering data, together with evidence of a knowledge of the fundamentals of engineering science sufficient, with further experience, to qualify for the higher professional grades. The completion of each full year of such standard course of engineering instruction shall be considered as the equivalent of one year of experience.

SUB-PROFESSIONAL SERVICE.

Grade 6.—Senior Aid, Office: Duties.—To supervise the plotting of notes and maps, and to direct the work of a drafting or computing squad.

Qualifications.—Experience for at least five years in tracing, lettering, drafting, and computing, of which at least three years shall have been spent in the duties of draftsman. Education equivalent to graduation from high school. The completion of each full year of a standard course of engineering instruction in an educational institution of recognized standing shall be considered as the equivalent of the experience otherwise required, with the provision, however, that at least one year shall have been spent in the duties of draftsman.

Grade 6.—Senior Aid, Field. Duties.—To direct work of field party on surveys or construction; to keep survey notes and engineering records; to supervise construction or repair work; to direct the work of computing surveys and estimates; to direct the work of making minor engineering computations.

Qualifications.—Experience for at least five years in the use and care of surveying instruments, of which at least three years shall have been spent in the duties of instrumentman. Education equivalent to graduation from high school. The completion of each full year of a standard course of engineering instruction in an educational institution of recognized standing shall be considered as the equivalent of the experience otherwise required, with the provision, however, that at least one year shall have been spent in the duties of instrumentman.

Grade 7.—Aid, Office. Duties.—To perpare general working drawings where design is furnished; to plot notes and prepare maps; to design simple structures; to make computations and compile data for reports and records; to check plans, surveys, and other engineering data.

Qualifications.—Experience for at least two years in tracing, lettering, drafting, and computing. Education equivalent to graduation from high school and familiarity with the use of the slide rule, and of logarithmic and other simple mathematical tables. The completion of each full year of a standard course of engineering instruction in an educational institution of recognized standing shall be considered as the equivalent of the experience otherwise required.

Grade 7.—Aid, Field: Duties.—To run surveying instruments and to adjust and care for same; to compute surveys and estimates; to make minor engineering computations; to inspect incidentally construction or repair work.

Qualifications.—Experience for at least two years in the duties of rodman. Education equivalent to graduation from high school and familiarity with the construction, operation, and care of surveying instruments. The completion of each full year of a standard course of engineering instruction in an educational institution of recognized standing shall be considered as the equivalent of the experience otherwise required.

Grade 8.—Junior Aid, Office: Duties.—To trace and letter maps and plans; to make simple drawings from sketches and data; to make minor calculations.

Qualifications.—Education equivalent to graduation from high school.

Grade 8.—Junior Aid, Field: Duties.—To run tape or levelling rod; to perform other miscellaneous subordinate duties in survey party in field or office, as directed.

Qualifications.—Education equivalent to graduation from high school.

Experience Equivalents for Post-Graduate Work.—The completion of each full year of post-graduate work in the specific subject of study or investigation appropriate to a particular service or branch of service shall be considered the equivalent of 1½ years of general experience, but such substitution shall not thus be made for more than four years of such experience or be considered as reducing the requirements in any grade of the number of years engaged in the conduct or direction of responsible work.

An examination of the schedule shows that the minimum experience requirements for the various grades may be briefly summarized as follows:

Service.	Grade.	Experience in years With degree in engineering.	Experience in years Without degree in engineering.
Sub-professional	8—Junior aid	0	0
	7—Aid	0	2
	6—Senior aid	0	5
Professional	5—Junior assistant engineer	0	4
	4—Assistant engineer	2	6
	3—Senior assistant engineer	5	9
	2—Engineer	8	12
	1—Chief engineer	12	16

The following table illustrates the practicability of adapting the proposed classification to any particular grade or branch of the engineering service and in such a way as to clearly retain a description of the relative rank.

PROFESSIONAL SERVICE.

1—Chief Engineer.

Chief engineer
State engineer
City engineer
Chief engineer of maintenance of way
Deputy chief engineer
Deputy state engineer
Deputy city engineer
Director, etc.

2—Engineer.

Electrical engineer
Mechanical engineer
Mining engineer
Chemical engineer
Bridge engineer
Sanitary engineer
Tunnel engineer
Maintenance of way engineer
Signal engineer
Highway engineer
Division engineer
District engineer
Sewer engineer
Topographical engineer
Landscape engineer
Hydraulic engineer
Geodetic engineer
Structural engineer
Valuation engineer
Designing engineer, etc.

3—Senior Assistant Engineer.

Senior assistant electrical engineer
Senior assistant mechanical engineer
Senior assistant mining engineer
Senior assistant chemical engineer
Senior assistant bridge engineer, etc.

4—Assistant Engineer.

Similar to senior assistant engineer

5—Junior Assistant Engineer.

Engineer inspector, etc.

SUB-PROFESSIONAL SERVICE.

6—Senior Aid.

Office: Chief draftsman
Chief computer
Field: Chief instrumentman
Chief inspector

7—Aid.

Office: Draftsman
Computer
Field: Instrumentman
Inspector

8—Junior Aid.

Office: Junior draftsman
Tracer
Field: Rodman
Tapeman

Striking Comparison of Results of Investigations Into Compensation.—In 1913 a committee was appointed by the board of direction of the American Society of Civil Engineers to investigate the conditions of employment and compensation of civil engineers. This committee was headed by the late Alfred Noble, who was succeeded as chairman by Nelson P. Lewis. In its final report, presented at the annual meeting of the Society held in 1917, the committee gave the results of its canvasses, comprising returns from 6378 engineers, of whom 1319 were non-members. The distribution among the various services of such returns as could be classified showed an average compensation as follows:

Service.	Number of classified men.	Average compensation.
States and countries	387	$2,735
National governments	575	2,899
Municipalities	764	2,994
Technical schools	262	3,240
Railroads	814	3,325
Private companies	2,198	4,240
Consulting engineers	620	6,737
Contractors	165	7,678
	5,785	$4,032

The committee advised that the analysis of the returns showed that the pay received by members of the society was generally about 25 per cent above that of non-members. It also stated that an effort had been made to obtain information from railroad, municipal, state, and federal departments but that the officials in authority considered it impracticable to undertake a collection of the desired data, and in the absence of this co-operation no headway could be made. The committee also reported that from the meager information obtained it was "convinced that the compensation for engineering work compares favorably with that received by men of any other profession," and that there was need for "better trained engineers rather than for more engineers."

That a radical change of heart has since taken place on the part of responsible department heads is clearly evidenced by the fact that practically the entire federal engineering service, except the War Department, has co-operated in the present inquiry, as has also 42 per cent of the state officials, and 70 per cent of the municipal officials, and that the financial status of 10,089 men in these grades has now been revealed as compared with a total of 1,726 men in the same classes of service, who replied to the 1913-1916 inquiry. It also appears that the respondents in the case of the previous investigation were largely confined to the classes receiving maximum compensation, the average rate of present compensation shown by the new return being as follows:

Service.	No. of men.	Average compensation.
Federal Government—Navy Department	594	$2,474
Federal Government (excluding War and Navy Departments)	3,956	1,814
Federal Government (excluding War Department)	4,550	1,900
State	2,222	1,700
Municipal	3,317	1,820

In comparing these returns with those received by the previous committee, the decrease in the value of the dollar should also be borne in mind.

Results from Questionnaires.—Tables I., II. and III. include partial results of the analysis of federal, state and municipal returns from questionnaires received up to the date of the committee report, Dec. 15, 1919.

TABLE I—FEDERAL SERVICE, SUMMARY OF PRESENT SALARIES BY GRADES.

		16 Engineering Bureaus in Civil Establishments.					4 Engineering Bureaus in Navy Department.				
Grade.	General description of duties.	No. of persons.	Present pay per annum. Average.	Present pay per annum. Maximum.	Present pay per annum. Minimum.	Per cent increase of the average since July 1, 1915.	No. of persons.	Present pay per annum. Average.	Present pay per annum. Maximum.	Present pay per annum. Minimum.	Per cent increase of the average since July 1, 1915.
1.	Chief administrative officer having full charge of organization including determination of policy.	15	$5,867	$10,000	$4,500	3.0	2	$9,450	*$9,900	*$9,000	0.0
2.	Chief of major subdivision in responsible charge of large unit	83	3,801	7,500	1,800	5.0	4	6,381	*9,000	5,200	0.0
3.	Chief of intermediate subdivision in responsible charge	209	3,104	5,000	1,800	9.9	22	4,312	5,634	2,304	57.6
4.	Chief of minor subdivision	846	2,222	4,500	1,020	9.0	54	3,600	4,883	2,304	58.2
5.	On general duty under direction but requiring special education and training and the use of initiative and originality	1,353	1,719	3,000	1,000	13.3	192	2,818	3,756	1,878	52.2
6-7.	On subordinate duty requiring special education or training but not requiring special originality	1,092	1,293	2,817	600	12.0	218	1,954	4,257	1,500	38.4
8.	On subordinate duty but not requiring special education, training or originality	169	975	1,340	480	19.3	81	1,379	2,254	1,002	37.2
	On special duty of responsible character requiring special qualifications and initiative	189	1,812	7,500	1,200	3.9	21	2,717	4,382	1,628	1.3
	Total	3,956					594				

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*Naval officers, all others are civilian.

It is thus disclosed that the average compensation for grades representing 68 per cent of the engineers in the Federal Service, other than the War Department, and 86 per cent of those in state and municipal service, is less than is required for the support of a family on a scale sufficient to provide for necessities (assumed at $2,200 per annum), to say nothing of the expense of giving children anything like the education with which the breadwinner was equipped.

It would seem reasonable to assume that men in the "Junior Aid" grade have not reached an age which would require compensation sufficient to support a family, but that the salary limitation for men in higher grades should clearly be sufficient to meet this need. On this basis it is safe to state that with anything like suitable compensation, not more that about 25 per cent of the entire service, if properly organized, should receive less than $2,200 per annum. The investigation made by the state and municipal section shows that the average age of the present incumbents of the lowest grades is actually about 27 years; if they are to be adequately provided for as permanent employes, the percentage of men to receive less than $2,200 is clearly negligible.

A comparison with the pay of the industrial worker who serves under the engineer also bears testimony to the fact that, while admitted by none as to value, the actual compensation for brawn is today greater than for engineering brain. The need for setting up some scale of compensation for the engineer to correct this serious condition is, therefore, obvious, as is also that for the inquiry now being carried on by the committee. Unless a radical improvement can be brought about, it seems evident that the profession cannot attract to or retain in it men of the caliber required to command the respect in which it has heretofore been held by the public, and that so long as they are continuously struggling with the problem of making even a bare living, their efficiency will be minimized and their incentive to work with other than a purely selfish interest will be lacking.

That a serious condition of unrest exists in the municipal and state services is clearly evidenced by explicit statements in this respect in 44 per cent of the questionnaires returned, while in only 13 of these services were conditions as to morale reported to be satisfactory.

From the investigation made by each of the sections of the committee, it appears that the heads of 16 engineering bureaus in the federal government (excluding the Navy Department) have recommended an average increase in present compensation averaging about 59 per cent, while similar increases in the state and municipal services, as recommended by the engineering heads, average 26 per cent.

As a result of the inquiry now in progress under the direction of the Congressional Joint Commission on Reclassification of Salaries, the attention of all members of the federal service has been drawn to this question in such a way as to make it one of close study and analysis, which condition doubtless accounts for the comparatively modest recommendation made by the representatives of the state and municipal services, whose reply to the Engineering Council Committee's inquiry has been individual and who have doubtless been confronted with the necessity of recognizing relationship to other workers in the same services in whose interests no concerted move of this character has been attempted.

The committee is impressed with the method which has been followed by the federal section in setting up a standard of compensation based on a readjustment to the new conditions as to cost of living, this being dependent on an award made on October 24, 1918, by the shipping wage adjustment board, which was designed to provide uniform national wage scale for all shipbuilding workers, including a scale of compensation for draftsmen and copyists. It is also understood that this wage scale, which is generally known as the Macy scale, has since been adapted with modifications to the needs of certain bureaus in the Navy Department. In the accompanying diagram here is illustrated a comparison of the compensation fixed under the Macy scale with the maximum rates suggested by the federal section. A further comparison has also been made with scales proposed by other organizations, which seem to justify the schedule of salaries now suggested by the committee for discussion, which is as follows:

TABLE II—STATE SERVICE. ANALYSIS OF RETURNS SHOWN BY 35 QUESTIONNAIRES FROM 27 STATES.

Position.	Number of persons now in position.	Age, Years* Range.	Age, Years* Average.	Average Compensation per Annum.* July 1, 1915.	July 1, 1919.	Recommended.†	Per cent increase in compensation over July 1, 1915.* Actual on July 1, 1919.	Recommended.†
Professional:								
Chief engineer	31	30-70	41	$3,743	$4,481	$7,124	20	90
Deputy chief engineer	19	30-51	38	3,352	3,616	4,477	8	34
Engineer	80	30-50	37	2 530	3,019	3,934	19	56
Senior assistant engineer	111	30-50	32	1,981	2,429	3,222	23	63
Assistant engineer	396	27-42	33	1,657	2,140	2,758	29	66
Junior assistant engineer	529	21-36	27	1,130	1,595	2,100	41	86
Staff	1,166	21-70		$1,590	$2,070	$2,730	30	72
Sub-Professional:								
Senior draftsman	29	25-40	31	$1,508	$1,868	$2,327	24	54
Draftsman	141	22-50	28	1,224	1,653	1,944	35	59
Junior draftsman	110	20-25	22	924	1,227	1,394	33	51
Chief instrumentman	61	24-40	27	1,297	1,611	1,915	24	48
Instrumentman	193	22-30	23	1,243	1,498	1,773	21	43
Rodman	522	18-26	20	791	1,057	1,148	34	45
Staff	1,056	18-50	..	$ 995	$1,290	$1,470	30	48
Entire service	2,222	18-70	..	$1,310	$1,700	$2,130	30	63

*Based on such returns as are complete. †As recommended by the engineering heads replying to questionnaire.

TABLE III—MUNICIPAL SERVICE. ANALYSIS OF RETURNS SHOWN BY 66 QUESTIONNAIRES FROM 40 CITIES.

Position.	Number of persons now in position.	Age, Years* Range.	Age, Years* Average.	Average Compensation per Annum.* July 1, 1915.	July 1, 1919.	Recommended.†	Per cent increase in compensation over July 1 1915.* Actual on July 1, 1919.	Recommended.†
Professional:								
Consulting engineer	8	39-70	55	$5,157	$6,410	$8,550	18	57
Chief engineer	64	30-64	44	5,424	5,467	7,165	1	38
Deputy chief engineer	19	35-60	48	4,624	4,901	6,320	6	37
Engineer	165	30-68	46	3,416	3,679	4,749	7	38
Senior assistant engineer	265	30-64	41	2,428	2,616	3,293	8	36
Assistant engineer	505	27-53	40	1,902	1,399	2,613	5	37
Junior assistant engineer	452	25-45	34	1,415	1,548	1.812	9	28
Staff	1,478	25-70		$2.230	$2.370	$3.020	6.5	36
Sub-Professional:								
Senior draftsman	100	28-53	42	$1,777	$1,982	$2,356	12	33
Draftsman	442	25-65	35	1,395	$1,626	2,008	17	41
Junior draftsman	118	21-48	26	1,055	1,205	1,439	14	36
Chief instrumentman	88	28-53	40	1,454	1,700	2,162	17	49
Instrumentman	178	22-52	38	1,174	1,126	1,737	21	48
Rodman	613	17-52	32	868	1,056	1,352	22	56
Staff	1,539	17-65	..	$1,160	$1,370	$1,700	18.5	47
Entire service	3,317	17-70	..	$1,640	$1,820	$2,290	11	40

*Based on such returns as are complete. †As recommended by the engineering heads replying to questionnaire.

Grade	Total years experience required to qualify, With professional degree.	Total years experience required to qualify, Without professional degree.	Salary Range Minimum.	Salary Range Maximum.
8—Junior aid	....	0	$1,080	$1,560
7—Aid	..	2	1,680	2,400
6—Senior aid	..	5	2,520	3,240
5—Junior assistant engineer	0	4	1,620	2,580
4—Assistant engineer	2	6	2,700	4,140
3—Senior assistant engineer	5	9	4,320	5,760
2—Chief engineer	8	12	5,940	No limit
1—Chief engineer	12	16	8,100	No limit

Applying the average proposed salary to the present incumbents of these positions as reported in the state and municipal services, it will be found that there would be a resulting increase in annual compensation totaling about $5,500,000 as compared with a total increase of $2,500,000 recommended by the service heads, against which should, however, be charged the economy growing out of the increased efficiency brought about by a restoration of morale.

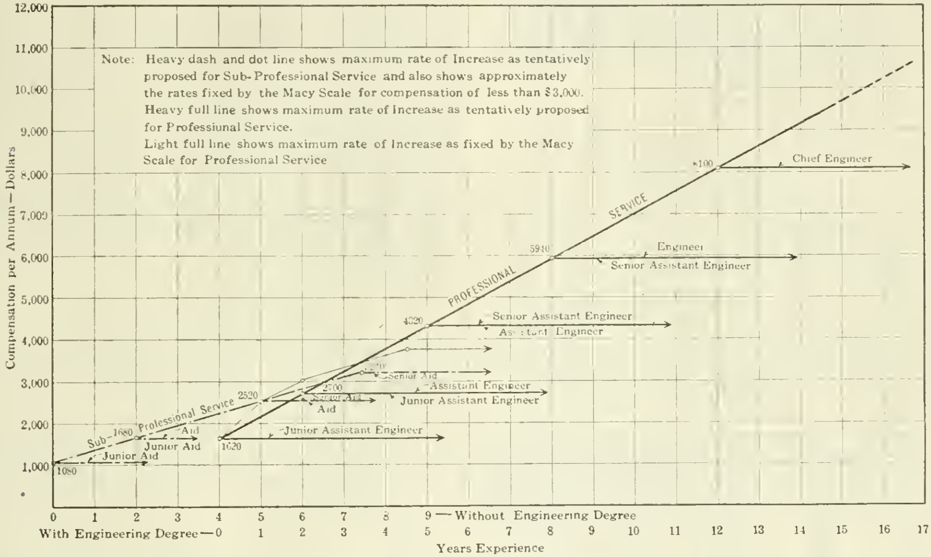

Diagram Showing Maximum Rate of Progress Through the Various Grades as Adopted, and Also Indicating the Compensation Tentatively Proposed for Each Grade.

The committee is not prepared at this time to recommend the adoption of any definite schedule of compensation, and it is not at all clear as to the wisdom of fixing even a minimum limit on the highest grades of service or of keeping the maximum of one grade below the minimum of the grade above, all of which questions are now receiving its serious consideration, as is also the question concerning the provision to be made for advancing within the limits of a grade, for which a plan is suggested by the federal section. Under this plan it is proposed at yearly intervals, through ratings determined by a personnel board, to provide for awarding an increase in compensation to three-fourths of the men in a grade receiving less than the maximum compensation of the grade, who through fitness and industry have shown themselves to be of increased value to the service. Those in the highest third of this preferred list would each receive the maximum rate of increase, which under the proposed scale would be $480, while each of the next two-thirds would receive an increase of $240, the latter figure corresponding with what would then be the average increase for all of the men in the grade.

It would seem to the committee that, pending the completion of the investigation, the scale of compensation herein presented and the plan for promotion within a grade is adapted to general use in all branches of engineering service. The committee believes, however, that a genral discussion of this question is desirable.

The Engineering Council's Committee on Classification and Compensation of Engineers consists of the following: Arthur S. Tuttle, chairman, Deputy Chief Engineer, Board of Estimate and Apportionment, Municipal Building, New York; Francis Lee Stuart, Consulting Engineer, 50 East 42nd St., New York City; John C. Hoyt, Chief, Division of Water Resources, U. S. Geological Survey, Washington, D. C.; Charles Whiting Baker, Consulting Editor, Engineering News Record, 31 Nassau St., New York City; M. O. Leighton, Chairman, National Service Committee of Engineering Council, 502 McLachlen Building, Washington, D. C. Railroad section: Francis Lee Stuart, Chairman; Frank H. Clark, Consulting Engineer, 15 Park Row, New York City; Bion J. Arnold, Consulting Engineer, 105 S. La Salle St., Chicago, Illinois. State and municipal section: Arthur S. Tuttle, chairman; M. M. O'Shaughnessy, City Engineer, San Francisco, Cal.; F. W. Cappelen, City Engineer, Minneapolis, Minn. Federal section: John C. Hoyt, chairman; John S. Conway, Assistant Commissioner of Lighthouses, Washington, D. C.; Oscar C. Merrill, Chief Engineer, Forest Service, Washington, D. C.

Cost of Water Purification at Cincinnati, O.—The average cost of operating and maintaining the filter plant of Cincinnati, O., for the 10-year period 1908-17 has been $3.96 per 1,000,000 gal. of filtered water delivered for consumption. This total consists of $1.66 for coagulating chemicals, 36 ct. for maintenance and $1.94 for other operating costs, principally labor charges. The following table, from the 1917-18 report of the Water Department summarizes the cost since the plant was started:

Year.	Operation: Coagulating chemicals.	Operation: All other operating costs.	Maintenance.	Total.
1908	$1.72	$2.47	$0.05	$4.24
1909	1.89	2.28	.09	4.26
1910	1.93	1.98	.28	4.19
1911	1.86	1.91	.35	4.12
1912	1.78	1.68	.38	3.84
1913	1.67	1.77	.48	3.92
1914	1.21	1.78	.39	3.38
1915	1.43	1.86	.76	4.05
1916	1.27	1.80	.38	3.45
1917	1.86	1.85	.40	4.11
1918	2.12	2.37	.67	5.16

Cost of Repairing Meters at Cincinnati, O.—The average cost of repairing meters by the Water Department of Cincinnati, O., for 1917 and 1918 was as follows:

	1917.	1918.
5/8-in.	$3.54	$3.75
3/4-in.	4.12	4.10
1 -in.	5.02	4.25
1½-in.	....	7.17
2 -in.	....	8.29
3 -in.	....	9.87

The above costs, taken from the annual report of the department, include test charges.

Duty of Irrigation Water in Western Canada

Practical experimental work to determine the proper duty of irrigation water in western Canada is being carried out by the irrigation branch of the Department of Interior of Canada. The following summary of the results of these investigations is taken from a paper prepared by Mr. F. H. Peters, Commissioner of Irrigation, for presentation at the Western Professional Meeting of the Engineering Institute of Canada, and printed in the December Journal of the Institute.

The two principal duty of water experiment stations are now at Brooks, and Ronalane, Alberta. An experiment station was previously operated at Strathmore, Alberta, and similar work is also being done at the present time in the Coaldale irrigated district near Lethbridge. The work which has been done at these stations gives general results which are typical for the larger irrigated blocks which have already been developed, or are proposed to be developed in the future. Up to the present there has been no opportunity to study very closely the question of local variations.

The method of carrying on these experiments is such as to give definite and positive results. A piece of land is selected which has consistent characteristics throughout and this is then divided up into a number of smaller plots. To determine the duty of water for wheat for example, perhaps ten of these plots are sown to wheat. They are then all treated exactly alike except that varying depths of water are applied. The first plot is left dry; the next receives 4 in.; the next 8 in.; the next 12 in., and so on up to a point where so much water is applied that the yield is actually decreased. This method definitely fixes the quantity of water which produces the maximum yield of all the different crops which are experimented with. This work is all checked by determining from soil moisture investigations the quantity of available water in the soils, both in the spring and in the fall of the year. Sometimes with the deeper rooted plants, the plots which do not receive sufficient irrigation water draw on the available moisture which was in the soil in the spring, and conversely with some of the plots that receive large quantities of water, the plants cannot use all of the water supplied and some of it is stored up in the soil. By determining the quantity of water available in the soil in the spring and again in the fall, it can be determined definitely just what quantity of water has actually been used by the plants during the growing season.

This experimental work shows just what results are gained from the different crops by applying different depths of water, and finally shows the depth of water which produces the maximum yield. It does not follow, however, that the quantity which produces the maximum yield should be adopted in fixing the duty of water. In fixing the legal duty of water there are practical considerations which have to be taken into account. It may not pay under practical conditions to supply the quantity of water which will produce the maximum crop yields. It may be much better to fix a duty which can be readily applied and at the same time give a large increase in crop yield. After a certain quantity of water has been applied, it usually takes a comparatively very large quantity of water to produce additional gains in the crop. Another practical point which has to be considered is the desirability of conserving the water supply which is available in the streams. Particularly with low priced dry lands, the value of a certain quantity of water may be much greater if spread over a larger area. That is to say, 1½ acre-feet of water spread over one acre of land might produce 50 bu. of wheat, while ¾ acre-foot spread over one acre might produce 35 bu. Thus if 1½ acre-feet were spread over two acres of land, it could be made to produce 70 bu.

The original duty of water in Western Canada was fixed by requiring a continuous flow throughout the irrigation season of 1 cu. ft. per second for each 100 acres of land. This figures out to a duty of 3 acre-feet, giving a depth of 3 ft. of water all over the land. Later the duty was changed requiring a continuous flow of 1 cu. ft. per second for 150 acres of land, which is equal to 2 acre-feet or a depth of 24 in. over the land. On March 25th of the present year, the duty was

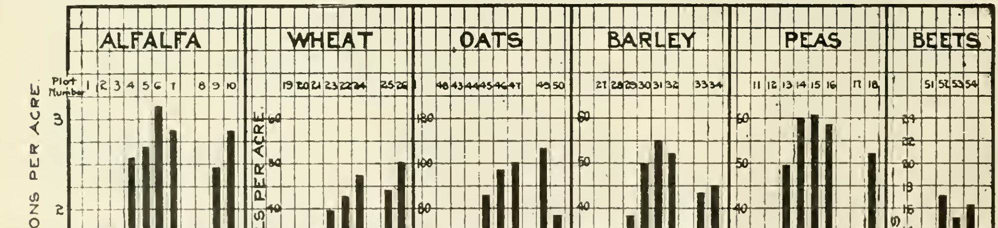

Diagram Shows Yields Produced In Comparison With Irrigation Water Applied, Ronalane, Alberta, 1917.

again changed and fixed at 1½ acre-feet for each acre of land, which equals a depth of 18 in. The investigations which have been made by the department indicate that with a system constructed so as to give a delivery of water at proper rates for practical use, that 1½ acre-feet is sufficient under the general conditions in Western Canada, and is a proper general duty of water.

The diagram which is printed below shows at a glance the kind of information that is gained in carrying on the duty of water experimental work. The diagram shows the results actually gained at Ronalane during the season of 1917. The diagram is divided off, to show the various crops on which experiments were made. Above the central horizontal line the columns represent the crop yield, and similar columns plotted underneath the central line show the depths of water which produced the crops. The column below the line representing the depth of water which produced the maximum yield is shown cross hatched with a view to bringing it more prominently before the eye. It is very evident from this diagram just how the crops increase as the depth of water applied is increased, until one reaches a point where too much water keeps the land wet and cold, and the crop yield begins to fall off again. As an exception, the greatest depth of water applied produced the greatest yield of wheat, but this particular experiment was not carried far enough to prove that an increased quantity would have decreased the yield. It will be noted that in the alfalfa crop the first group of columns shows the application of 4-in. irrigations, while the second group shows the results from the application of 6-in. irrigations. Similarly for the wheat, oats, barley and peas, the main group of columns shows 4-in. irrigations, while the last two in each case show 6-in. irrigations.

Water Waste Warnings

The Department of Water Supply of New York City is conducting a campaign to reduce the waste of water caused by leaky fixtures and carelessness of the consumer. In a bulletin issued by the department the following warnings are given to householders:

Do You Know?—Half a million leaky fixtures are within buildings in New York City.

One hundred million gallons of water are wasted every day from those leaky fixtures.

Forty thousand tons of coal will be used every year to pump this wasted water.

Three-quarters of a million dollars will be spent annually to supply this wasted water.

One-third of the total supply from the new Catskill system is wasted.

Two-thirds of the total supply from the new Catskill system is not enough for our legitimate needs.

What You Can Do.—Don't let the water run longer than absolutely necessary.

Don't try to keep milk cold by running water over it. Put it in a pail of cold water.

Don't turn the faucet on and forget it. Turn it off as soon as you are through.

Don't turn the faucet on so as to give you a larger stream than you need.

Don't have leaking fixtures. If you hear a continuous noise from the water pipe, water is wasting somewhere. Find the leak if you can, and fix it.

Don't let the water run in the winter time to prevent it from freezing, unless absolutely necessary on very cold nights and then only run a small stream. Protect the water pipes from frost.

Billing Machines Save Time in Getting Out Water Bills.—The Accounting Division of the Water Works Department of Cincinnati, O., handles 65,000 accounts each month. About 45,000 meters and 290 elevators are read monthly by 23 meter readers within 17 days. Reports of meter readers are then transferred to ledger cards by clerks, who figure the consumption and cost of water. The ledger cards then pass to four billing machine operators, who prepare the bills and ledger in one operation by means of permanent carbon used on back of meter bills, turning out about 3,600 bills and preparing the same number of ledger accounts daily, after which bills are compared with ledger cards and the ledger sheets audited. As a courtesy, all bills are delivered, consuming about 5½ days monthly.

The Value of a Hydraulic Horsepower at the Wheel*

By E. W. RETTGER,

Assistant Professor, Applied Mechanics, Cornell University.

In an article entitled "Economical Size of Pipe for a Given Loss of Head," in the Cornell Civil Engineer of April, 1919, the writer solved the following problem:

Given a pipe of fixed length, l, and under a given head, h, with a given discharge, q, it is required to find the size of the pipe so that for a given or assumed total loss of head, h′, due to friction in the pipe the annual cost of the pipe (or the first cost, or the amount of metal as the case may be) will be a minimum.

If the pipe has a uniform diameter throughout, the problem is comparatively easy. The writer has special reference, therefore, to a pipe under high head where it is desired to make this pipe consist of two or more sections of different diameters and different thickness of shell. Theoretically, the most economical pipe is one in which the diameter decreases as the head increases. In practice, however, the pipe is made to consist of two or more sections, each section of constant diameter and thickness of shell. The greater the number of sections, the nearer will the pipe approach the theoretically most economical pipe.

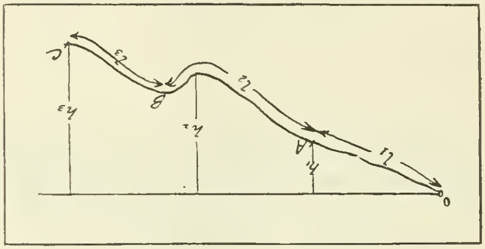

Fig. 1.

For convenience, the pipe was assumed to consist of three sections OA, AB and BC, of lengths l_1, l_2, and l_3, respectively. The highest heads the respective sections are under are h_1, h_2, and h_3 (see Fig. 1).

Evidently, the location of the points of division, A and B, will affect the economy. No general solution can be given which will determine the position of the most economical points of division. These points can best be determined perhaps by trial. It was assumed therefore that the location of the points that divide the pipe into sections were known. These points need not be the most economical points. Consequently, l_1, l_2, and l_3 and h_1, h_2, and h_3 were all assumed as known. That is, it was assumed that the length of each section and the highest head it was under were given, and it was required to find the diameters of these sections so that the pipe as a whole would entail the minimum annual cost or minimum first cost, or would contain the minimum amount of metal as the case may be, subject to the condition that the total loss of head in the pipe due to friction should equal h′.

Formulas for Determining Economical Pipe for Least Annual Cost—For riveted steel pipes, the writer found that the solution of the problem was given by the following equations:

$$(1)\quad d = 0.2195\sqrt[6]{\frac{f\,b\,q^2}{t'\,c\,i}}$$

applicable to a section under low head, and

$$(2)\quad d = 0.2153\sqrt[7]{\frac{f\,b\,q^2\,S}{c\,i\,h}}$$

applicable to a section under high head.

In these equations, f is the coefficient of friction as given by the equation $h' = \frac{f\,l}{d}\cdot\frac{v^2}{2g}$; S is the allowable unit stress in shell in pounds per square inch, corrected for rivet holes and water hammer; c is the cost of the metal per pound; i is the rate of interest and depreciation on first cost of pipe; q is the discharge in cubic feet per second; h is the highest head the section under consideration is under; t′ is the minimum allowable thickness of shell: and b is a parameter to be determined.

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*From the Cornell Civil Engineer.

In the article cited above, the writer showed how the value of the parameter b can be found for any case, and he pointed out that in most cases the simplest method of procedure was as follows: Assume a value for the parameter, b, and determine the diameters of the several sections of the pipe by means of equations (1) and (2). The total loss of head due to friction in this pipe can then be found. If this equals h′, the amount specified, the problem is solved. If not, other values for b should be successively assumed until the pipe is found for which the total loss of head is h′.

Equations (1) and (2) contain f, the coefficient of friction, which is not known to start with. To eliminate this unknown f, the writer developed the following equations:

$$(1')\quad d = 0.1356\sqrt[6.]{\frac{b\,q}{t'\,c\,i}}\qquad \text{for low head}$$

and

$$(2')\quad d = 0.1423\sqrt[7.25]{\frac{b\,q\,S}{c\,i\,h}}\qquad \text{for high head.}$$

In many cases the saving in the amount of metal required if the pipe under high head is designed for several sections of different diameters and thickness of shell over that required if these sections are designed all for the same diameter, but for different thickness of shell, is hardly enough to justify the expense of the reducers. The writer, therefore, developed a formula for a pipe under high head (or part of the pipe), if all the sections shall have the same diameter but different thickness of shell. He discovered that formula (2), or (2′) is applicable if for h in this formula we put $h_.$, where

$$h_. = \frac{h_1 l_1 + h_2 l_2 + h_3 l_3}{l_1 + l_2 + l_3}$$

in which h_1, h_2, h_3 and l_1, l_2, l_3 have the same meaning as above (see Fig. 1.).

Formulas (1) and (2) [or (1′) and (2′)] determine the economical pipe for the least annual cost. If $i = 1$, they will determine the pipe for least first cost; and if $c = i = 1$, they will determine the pipe of least amount of metal. These formulas hold only for riveted steel pipes, homogeneous throughout, and for such pipes the pipe of least amount of metal will be the pipe of least first cost or least annual cost. Formulas similar to the above can be derived, however, for each kind of pipe, and if a section of the pipe (say the upper) is made of different material from that of the other sections, the appropriate formula must be applied to that section. It is not a question now of least amount of metal, but rather one of least first cost, or least annual cost.

Application of Formulas Formulas (1) and (2) [or (1′) and (2′)] may be used to solve a variety of problems. Suppose, for instance, it is required to find the pipe for which the percentage return on original investment shall equal a specified amount. To find this pipe, assume values for b successively and for each assumed value for b determine the pipe and calculate the percentage return, p, on original investment. A curve may then be plotted with b as abscissa and p as ordinate. From this curve that value of b can be obtained that will determine the economical pipe for which the percentage return is the amount specified.

An examination of formulas (1) and (2) will show that they are the same as the formulas derived for the economical size of a pipe (riveted steel) from the point of view of Adams' Rule. This rule may be expressed as follows: That pipe is most economically designed for which the interest and depreciation on first cost of pipe plus the annual value of the power lost due to friction in the pipe is a minimum.

For convenience we will again assume that the pipe is to consist of three sections as shown in Fig. 1. The points of division, A and B, are assumed as given. Let I_1, I_2 and I_3 be the interest and depreciation on the first cost of the respective sections. Then $I = I_1 + I_2 + I_3$ is the interest and depreciation on first cost of the pipe as a whole. Let h'_1, h'_2 and h'_3 be the losses due to friction in the respective sections so that the total loss is

$$h' = h'_1 + h'_2 + h'_3$$

Also, let B_1, B_2 and B_3 be the values of the power lost in the respective sections so that the total loss is

$$B = B_1 + B_2 + B_3$$

The power lost in the pipe is then

$$P = \frac{62.5\,q\,h'}{550} = \frac{q\,h'}{8.8}$$

and the value of the power lost is

$$B = bP = b\frac{qh'}{8.8} = \frac{bq}{8.8}(h'_1 + h'_2 + h'_3) = B_1 + B_2 + B_3$$

where b is the annual value of a hydraulic horsepower at the wheel. If we let

$$(4)\quad L = I + B = I + b\frac{qh'}{8.8}$$

$$= (I_1 + B_1) + (I_2 + B_2) + (I_3 + B_3) = L_1 + L_2 + L_3$$

where

$$(5)\quad L_1 = I_1 + B_1 = I_1 + b\frac{qh'_1}{8.8}$$

and similarly for L_2 and L_3, then according to Adams' Rule L must be a minimum. Now L is a function of d_1, d_2, and d_3, and for L to be a minimum the partial derivations of L with respect to d_1, d_2 and d_3 must separately be equal to zero, that is, we must have

$$\frac{dL}{d(d_1)} = \frac{dL}{d(d_2)} = \frac{dL}{d(d_3)} = 0$$

Now L_1 contains d_1 as the only variable (see equation 5). In like manner L_2 and L_3 contain d_2 and d_3 respectively as the only variables. Therefore (see equation 4)

$$\frac{dL}{d(d_1)} = \frac{dL_1}{d(d_1)}$$

and similarly for L_2 and L_3. The conditions that must be satisfied then for L to be a minimum are

$$\frac{dL_1}{d(d_1)} = 0,\ \frac{dL_2}{d(d_2)} = 0,\ \frac{dL_3}{d(d_3)} = 0$$

Or, in general, if the subscript r is used to designate any section (see equation 5)

$$(6)\quad \frac{dL_r}{d(d_r)} = \frac{d\,I_r}{d(d_r)} + b\frac{q \times dh'_r}{8.8 \times d(d_r)} = 0$$

for each section of the pipe.

Equation (6) leads to the formulas (1) and (2), or (1′) and (2′).

Formulas (1) and (2) contain b, the value of a hydraulic horsepower at the wheel. Nowhere so far as the writer knows is it shown just what should be taken for the value of a hydraulic horsepower at the wheel. Several interpretations may be given to b, and for these interpretations the results will be different. The writer, therefore, decided to determine for himself just what will be accomplished for each of several interpretations that may be given to b.

I. The first and most general interpretation for b has already been indicated in the first part of this article, namely, b may be taken as a constant or a parameter such that for every assumed value for b, formulas (1) and (2) will determine that pipe which for the resulting loss of head in the pipe will be the pipe of least annual cost or least first cost in least amount of metal as the case may be.

Interpretations that may be given to b, interpreted as the annual value of a hydraulic horsepower at the wheel.—Let C equal the annual cost of everything down to the end of the pipe line, but not including the pipe itself, and let K equal the annual cost of everything from end of pipe line on. In discussions of this kind it is usually assumed that the variation in the values of C and K due to a small variation in the value of the diameter d of the pipe is negligible when compared with the corresponding variation in the value of $L = I + B$. That is, it will be assumed that $\frac{dC}{d(d)} = 0$ and $\frac{dK}{d(d)} = 0$ when compared with $\frac{dL}{d(d)}$.

II. If b be taken as the annual commercial value of a hydraulic horsepower at the wheel, these formulas will determine that pipe for which the annual net profits on the part of the plant that includes everything from dam to end of pipe line will be a maximum. These profits are over and above all annual expenses, including the interest and depreciation on first cost of pipe.

Note. If one company owned the part from dam to end of pipe line and if it sold its hydraulic power to a second company the first company would be interested only in the profits derived from the part it owned.

The proof is as follows: The total net annual profits on the part from dam to end of pipe line are given by

$$b \frac{q\,(h - h')}{8.8} - (I + C)$$

since the available hydraulic horsepower at the end of the pipe line is

$$\frac{62.5\,q\,(h - h')}{550} = \frac{q\,(h - h')}{8.8}.$$

In the above expression, C is the annual cost of this part of the plant not included in I, and I is the interest and depreciation on the first cost of pipe.

Rearranging terms, the above expression may be written in the form

$$\frac{b\,q\,h}{8.8} - C - \left[I + \frac{b\,q\,h'}{8.8}\right]$$

This last expression will be a maximum if the quantity in brackets, that is, if L, is a minimum [See equation (4)]. Minimizing L leads to formulas (1) and (2). The proposition, therefore, has been proved.

III. If b be taken as the annual cost of producing a hydraulic horsepower at the wheel, this cost being based only on the annual cost of everything from dam to end of pipe line, these formulas will determine that pipe for which this cost will be a minimum (see Note above).

If, for convenience, we again assume that the pipe consists of three sections, b may be expressed by

$$(7) \quad b = \frac{I_1 + I_2 + I_3 + C}{q_1 \left(\frac{h - h_1' - h_2' - h_3'}{8.8}\right)}$$

where C may be thought of as a constant since $\frac{dC}{d\,(d)}$ is negligible compared with $\frac{dI}{d\,(d)}$. Now b is a function of d_1, d_2, and d_3, and for b to be a minimum the partial derivatives of b with respect to d_1, d_2, and d_3 must separately be equal to zero. Remembering that d_1 is contained only in I_1 and h_1', $\frac{d\,b}{d\,(d_1)} =$

$$\frac{b\left(\frac{h - h_1' - h_2' - h_3'}{8.8}\right)\frac{d\,I}{d\,(d_1)} + (I_1 + I_2 + I_3 + C).\frac{q}{8.8}.\frac{dh_1'}{d\,(d_1)}}{\left[q\,\frac{h - h_1' - h_2' - h_3'}{8.8}\right]^2} = 0.$$

Simplifying and making use of equation (7), we obtain

$$\frac{d\,I_1}{d\,(d_1)} + \frac{b\,q}{8.8}\,\frac{d\,h_1'}{d\,(d_1)} = 0,$$

and similarly for the other sections. That is, we must have

$$\frac{d\,L_r}{d\,(d_r)} = \frac{d\,I_r}{d\,(d_r)} + \frac{b\,q}{8.8}\,\frac{d\,h_r'}{d\,(d_r)} = 0$$

for each section of the pipe. This last equation is the same as equation (6) from which the formulas were derived. The proposition, therefore, has been proved.

IV. Let m be the annual commercial value of electric power (per horsepower) and let γ be the efficiency of plant from end of pipe line on, then, if $b = \gamma m$, these formulas will determine that pipe for which the total net annual profits on entire plant over and above all annual cost will be a maximum.

The total net annual profits on entire plant are

$$m.\gamma \frac{q\,(h - h')}{8.8} - I + (C + K)$$

where K is the annual cost of everything from end of pipe line on, assumed as practically constant when compared with I.

Putting $b = \gamma m$ and rearranging terms, this expression may be written

$$\frac{b\,q\,h}{8.8} - C - K - \left[I + \frac{b\,q\,h'}{8.8}\right]$$

This will be a maximum when the quantity in brackets, that is, when L for the whole pipe is a minimum. The proposition, therefore, has been proved.

V. If b be taken as the total annual cost per hydraulic horsepower developed at the wheel (that is, as the annual cost of the entire plant per hydraulic horsepower developed at the wheel), these formulas will determine that pipe for which this cost is a minimum.

That is,

$$b = \frac{I_1 + I_2 + I_3 + C + K}{q\left(\frac{h - h_1' - h_2' - h_3'}{8.8}\right)}$$

Proceeding as we did in III, it will be found that $\frac{d\,L_r}{d\,(d_r)} = 0$ for each section of the pipe. The proposition, therefore, has been proved.

The above five interpretations are not necessarily the only interpretations that may be given to the quantity b found in the standard formulas for the economical design of penstocks or pipes.

Metering Fire Services

Fifty out of a total of 230 strictly fire service lines at Utica, N. Y., were metered during the past season with results that warrant the completion of the work, according to Frederick E. Beck, Chief Engineer, Consolidated Water Co., Utica, N. Y., in a paper read by him at the annual convention of the New England Water Works Association.

It was decided to meter first those plants having outside yard systems and to proceed at such a rate that all services would be metered in four years.

All meters are located in brick or concrete pits as near as possible to the street line. All expense, including cost of meter, is borne by the company except for a nominal service charge of $40 for 4-in., $50 for 6-in. and $75 for 8-in. connections. The taker pays for all water passing through the meter, excepting that used for extinguishing fires or testing of equipment. In such cases, the customer is required to give notice on cards showing the time and duration of the fire. The allowance for water used for these two purposes is then based on the normal flow as shown by previous meter readings.

The cost of installing the meters on service lines already in use has averaged $153 for 8-in. meters and $135 for 6-in. meters, with a range of from $80 to $239 on the 8-in. size and from $75 to $182 on the 6-in. meters. These prices do not include pavement replacement, but include all other labor and material costs for placing meter and constructing meter pit.

On the 50 meters installed all but three show a constant flow of water, the three exceptions being new connections to buildings having no yard system and but small sprinkler systems. The rate of flow through the fire service connections varies from 6 to 3,000 cu. ft. per day.

Filter Operations at Cincinnati in 1918.—Low turbidities in the raw water and a shortening of the length of filtered runs, due to microscopic growths, at the filtration plant of Cincinnati, were met by "breaking" the filter beds. During the period in June when short periods of service were obtained, a loss of head of between 9 and 10 ft. was reached after the filters had been in service, on an average, only 6 hours. By "breaking" the beds three times, an average of 31 hours of filter service was obtained before the filter was given its final wash. During the year this procedure of "breaking" was practiced from June 24 to June 29 and from Aug. 15 to Sept. 13. The average period of filter service was 21.97 hours, practically the same as for the two preceding years. Water used for washing the filters amounted to 375.5 million gallons, or 1.78 per cent of the quantity of water filtered.

POWER AND PUMPING SECTION

This section of the Waterworks and Hydraulic Monthly issue of Engineering and Contracting is devoted to the selection of power and pumping equipment and the economic management of its operation.

How to Effect Economies in Steam Generating Stations

At no time has there been such an awakened interest in the subject of economic power plant operation as there is at present. One reason for this is the scarcity, high price and general inefficiency of labor. In a paper presented Dec. 4 before the New England Street Railway Club, Mr. S. M. Flinn of the American Engineering Co., Boston, pointed out that the proper selection of equipment was the most important factor in securing economy and efficiency in the steam generating plant. An abstract of the paper follows.

Coal Handling Equipment.—Power generation starts at the unloading of the fuel container, whether it be a coal car or a tank for fuel oil and at this very point economies start. Unloading coal cars by hand is as consistent today as emptying a tank car with a pail, yet there are many plants in New England which handle coal this way, although in general they are the smaller plants. To unload cars by hand requires labor, there is an appreciable loss of fuel, sometimes as high as 1 per cent in a spillage and coal left in the cars. There is probably not a single plant which could not build an elevated siding up which the cars can be run and dumped into a track hopper thus eliminating the shovel wielder and the losses due to wastage and the possibility of demurrage on the cars.

Assuming that the coal storage is a plot of ground, there comes the question of getting the coal into the boiler room. The wheelbarrow is an antiquated method still used in moving this coal in a great many plants and it is not necessary to consider installation of over-head conveying systems which it would be impossible to install in a great many old plants. The electric tractor offers an ideal solution for moving coal. Such a problem was encountered by a textile mill in Philadelphia that solved their difficulty by installing a tractor which hauled the dump cars around the yard. The installation had the effect of reducing the coal handling squad from 6 to 1 man; all the coal was piled by these tractors and in turn was carried from the coal pile to cars in front of the boilers and the total cost of handling the coal was less than 2 ct. per ton.

Locomotive cranes are frequently used for unloading and piling the coal in storage yards and are one of the very economic ways of handling coal, where a considerable quantity is used by day.

In connection with the coal handling equipment a very important auxiliary is a coal measuring device. It is of as much importance to keep a check on the coal burned per boiler as it is to keep a check on the weight of the coal delivered. We cannot expect to obtain conservation of fuel without checking the efficiencies obtained by the use of it. An automatic recording coal scale has a psychological effect upon the average fireman. The non-automatic recording coal scale has the effect of making the fireman dishonest in his endeavor to show low fuel consumption, but the recording scale does not lie. The scales are located usually at the top of the down-comers to the boilers.

Proper Selection of Stoker and Boiler.—One of the biggest items of conservation of coal fuel is in the proper selection of the stoker and boiler. Hand firing does not belong to the modern power plant. I am willing to grant that it is possible under ideal conditions and for a very short period of time to obtain an efficiency with hand firing probably equal to the best performance of stokers, but this is for only a short period, say two hours at the most and under ideal and low load conditions, starting with a clean fire, clean tubes, and at the end of that period the efficiency will start to drop and it will drop more rapidly the longer the test is kept up until it reaches a certain level, which except for short spasmodic periods will never be improved.

The boiler question is largely a matter of personal opinion of the engineers. To start and name all the good boilers on the market we would simply recount a list of practically all the boilers which you see advertised and the sole merits of one boiler over another lies principally in the facility with which repairs can be made, together with certain minor specific features in the different types of boilers which will make one engineer select one type rather than another. There is the standing of the company manufacturing the boiler, the service rendered by the boiler company and many other things that effect the selection, but as far as efficiencies are concerned the writer has found very little difference in the efficiencies obtained between the various types of boiler.

The design of the boiler setting is very important; however, a large combustion space with a stoker set flush with the front of the boiler is important. Vertical and inclined baffles are conceded by the engineering profession to be superior to the horizontal baffle hanging from or laid on the tubes. Superheaters built in the gas passes of the boiler setting proper instead of in a separate compartment are conceded by engineers, in the best location. Soot cleaners are necessary and the permanently built-in soot blower is certainly preferable to the old steam lance; tubes must be cleaned to permit of the proper convection of the heat also to prevent blistering tubes. The "once a day" use of the steam lance never was effective in cleaning tubes; the "once a watch" use of the built-in soot blower with every steam nozzle designed to clean its portion of the tubes has added greatly to the efficiencies of many a boiler installation. In connection with soot handling and disposal the horizontal baffle offers a more serious problem than the vertical baffle on which soot does not accumulate.

Ash and Soot Disposal.—Ash disposal, and with it you may consider soot disposal, is one of the most important things in the modern power plant and has probably received, until the very recent past, less consideration from engineers, than almost any other one item. One of the best methods of handling ashes is the old-fashioned wheel barrow method, which is condemned for every other modern use, but is still a mighty efficient one for ashes. Of course, in this the actual wheel barrow is not used, but the same principle, namely, the dumping of ashes or raking them into a car. The Long Island City Power Station of the Pennsylvania R. R. handles ashes from thirty-two 600-HP. boilers in this manner. They are dumped into iron tanks which are carried on flat trucks and are not pushed by hand to a hoist which lifts the tank without the truck up to a run-way where the tanks are carried on other cars out to the ash tower. Modifications of this system are working out very satisfactorily. The use of electric tractors or an endless cable have both been successfully adopted for hauling the ash cars. It is almost foolhardy to consider putting storage battery drives directly on the ash cars.

A modern type of conveyor that lends itself particularly well to the handling of ashes is the so-called vacuum system. The system that sucks the ashes is preferable to the one that drives the ashes for the simple reason that suction tends to draw the particles of ash to the center of the pipe producing the minimum wear on the pipe itself. A combination of these two methods of moving the ash is probably the best, namely, suction on the horizontal lines and forcing on the vertical lines. Much ingenuity has been exercised in designing the elbows of these conveyor pipes so that the parts that are actually subject to excessive wear are easily replaced.

A proper selection of auxiliary equipment both for the generators and for the boiler is most important. The rotary circulating pump driven by an electric motor is far more economical than a reciprocating pump. The modern high speed fan driven through reducing gears by a high speed turbine gives forced or induced draft at a much lower cost both for operation and maintenance than the old paddle wheel fan. The steam consumption for stoker auxiliaries should never exceed 2.5 per cent of the steam generated when exhausted into the atmosphere and actual tests show this figure to be as low as ¾ per cent when the steam is returned to a heater. Modern bucket conveyors are operated by motors ranging from 5 to 20 HP., dependent upon the size of the conveyor.

There is one thing yet that you can do tomorrow morning, in order to start your campaign of economy, and that is, to see that every steam joint, every valve steam packing, every piston rod packing, is tight; every grease cup is full; that there are no wobbly bearings on your shaft; that your recording meters are working; that you know they have been calibrated in the recent past, etc., etc., etc.

Underfeed Stokers Permit Overloading

It has been long known among boiler and stoker engineers that no danger need be feared in "driving" a well-designed boiler up to the limit of coal-burning capacity of the stoker. But the problem of getting higher ratings out of equipment has been to develop stokers which will be able to meet the more severe requirements. From the outset it was apparant that the natural draft of the highest chimneys would be inadequate to burn enough coal per square foot of grate surface to drive the boilers at the rate required to produce extraordinarily high ratings. About 40 lb. to 45 lb. of coal per square foot of grate surface per hour is the maximum combustion rate which can be attained with any natural-draft stoker. The size of the grate surface, of course, is limited by the size of the boiler, and consequently no relief could be had from that source. The forced-draft multiple-retort underfeed stoker appeared, however, and was found to possess coal-burning capacity running up to 80 lb. per square foot of grate surface per hour. In a paper presented last summer before the Nebraska Section of the National Electric Light Association, Mr. H. A. Lynette, of the Westinghouse Electric Manufacturing Co., points out how this development has stimulated boiler-room progress.

Improvements in design of boiler and stoker combinations during the last four years have been great. A few years ago about 200 per cent of boiler rating was considered the limit. In the modern central station today it is no uncommon thing to find boilers operated at 300 per cent or 400 per cent rating continuously, and much higher ratings are developed on peak loads of a few hours' duration.

For instance, one of the boilers at the Buffalo General Electric Co.'s generating station having a rating of 1,140 HP. was operated at 620 per cent rating for eight hours without damage to the boiler or stoker. At this rating the boiler was evaporating over 200,000 lb. of water per hour, while the stoker was burning over 10 tons of coal per hour. This unit was designed to operate 24 hours per day at 480 per cent of its rated capacity. It is possible to take one of these boilers with a banked fire and to reach 200 per cent rating within 6 minutes from the time the stoker is put in operation.

The first multiple-retort underfeed stokers were installed with much the same general type of boiler setting as had been the practice with other types of stokers in use. It was found, however, by experience in actual operation that some changes in setting, design and methods of application were desirable. High rates of combustion required larger combustion chambers than formerly, and intense fuel-bed temperature made it advisable to place the actual heating surface exposed to radiant heat further from the fuel bed in order to avoid the danger of blistering the tubes. At the same time it became apparent that anything in the way of arches or encircling tile which might interfere with the absorption of heat by radiation from the fuel bed was unnecessary from the standpoint of aiding combustion and undesirable from the standpoint of efficiency.

Such construction interferred with the absorption of heat by radiation and placed a burden on the boiler of heat absorption by convection which the boiler could not efficiently carry. The reason for this is clear when it is remembered that heat absorption by radiation varies approximately as the square of the difference in temperature between the heating surface of the boiler and the radiation surface of the fuel beds, whereas heat absorption by convection is in direct proportion to the difference in temperatures between the heating surface of the boiler and the temperature of the gases.

It is thus seen that it is extremely advantageous so to arrange the boiler and stoker combination so as to permit as large a part as possible of the heat to be absorbed by direct radiation from the fuel bed. The hot gases thus enter the actual tube region at a much lower temperature and the temperature of the gases leaving the boiler is lower in proportion. Owing to the intense fuel-bed temperature, it is desirable not only to eliminate arches and incircling tiles on the tubes but to eliminate any other boiler brickwork possible in the furnace region, thus reducing the amount of brickwork and maintenance.

Double stokering the boiler and thus eliminating entirely the bridge wall has been one of the greatest advances. Two things are thus accomplished. The bridge-wall brickwork is done away with and the double stoker so increases the amount of grate surface possible under the boiler that very much higher capacity may be developed without forcing the stokers to abnormal combustion rates.

One of the greatest fields of usefulness for the multiple-retort underfeed stoker lies in meeting the increased steam requirements of the existing plants. A typical case will probably illustrate this. A small utility plant was built 8 years ago, at which time the peak load was 1,800 kw. Four 500-HP. boilers were installed, of which three, operating at about 125 per cent rating, were sufficient to carry the load. After 5 years, the load had increased to 2,200 kw., making it necessary to force 3 boilers to the limit of their capacity, about 165 per cent rating. The company then had an opportunity to take on a new customer using 800 kw. To carry this increase would require two additional boilers and stokers. This extra equipment would necessitate considerable extension to the boiler house. The total cost would have amounted to about $90,000.

Instead of doing this, the four old stokers under the boilers were replaced by multiple-retort underfeed stokers, designed to operate the boilers continuously at 250 per cent rating and to meet peak loads of 300 per cent for 4-hour periods. The total available boiler output of the four boilers thus became 5,000 HP. continuously and 6,000 HP. for 4-hour periods. The total cost of changing to underfeed equipment was approximately $30,000. The over-all efficiency with the new stokers being considerably higher than was possible with the old ones, the fuel cost was reduced. The revamped plant also had greater flexibility than before.

Baltimore Makes Profit from Hog Feeding Farm.—The city of Baltimore in May, 1919, placed in operation a farm for utilizing garbage by feeding it for hogs. The farm is owned by the city and leased to the American Feeding Co. The city pays the cost of collecting garbage in the city as heretofore, and now pays for towing it to the farm. On the other hand the American Feeding Co. pays the city for each ton of garbage three and one-half times the average top price per pound of live hogs for the month on the Chicago market, so that the price received by the city fluctuates with the value of the hogs. For the last 4 months of 1919 the city received about $7,000. The cost of towing during this period was about $2,500, yielding a profit to the city shown not only by the actual receipt of money but by avoiding altogether the payment of money to a contractor, as in previous years, for the disposal of garbage, usually some $75,000 a year.

Annual Meeting of the Indiana Engineering Society.—The annual meeting of the Indiana Engineering Society will be held Jan. 23 and 24 at the Claypool Hotel, Indianapolis, Ind. Chas. Brossman, 1503 Merchants Bank Bldg., Indianapolis, is Secretary.

Annual Meeting of Ohio Engineering Society.—The 41st annual meeting of the Ohio Engineering Society will be held Jan. 20, 21 and 22 at the Southern Hotel, Columbus, O. Jno. Laylin, Norwalk, O., is Secretary.

Boiler Room Essentials

In the past it has been characteristic of steam power plant engineers to pay a great deal of attention to the economy of the prime mover and to neglect to a large extent the boiler room. The steam engine and turbine have been brought to a high standard of efficiency, and whatever future improvements may be made, the corresponding gain in efficiency will necessarily be small. On the other hand, the opportunities for saving in the boiler room are large. How this economy can be accomplished by installing efficient labor-saving equipment is pointed out by Mr. H. F. Gauss in an excellent article in Power from which the following is taken.

Automatic Stokers Reduce Operating Cost and Increase Efficiency.—Installation of additional equipment in the engine room will sooner or later necessitate more capacity in the boiler room, and unless the latter is already equipped with modern stokers and coal and ash-handling machinery, the logical move is to provide this equipment throughout, instead of adding to the present uneconomical apparatus.

Consider, for example, a boiler room containing six 350-HP. hand-fired boilers, four of which are in constant operation. Tests show that an efficiency of 60 per cent is maintained and three shifts of two firemen, two coal passers and two ashmen are required. A good grade of egg coal is necessary, and constant attention must be given the fires to maintain even 60 per cent efficiency.

By installing automatic stokers with coal and ash-handling machinery, the operating force can be reduced by one-half and an efficiency of 70 per cent secured, a cheap grade of coal can be burned and a more uniform condition of operation maintained. The comparative cost of operation is given approximately in the accompanying table:

COST OF HAND-FIRING VS. STOKER OPERATION.

Old Equipment.	
6 firemen at $5 per day	$ 30.00
6 coal passers at $4.50 per day	27.00
6 ash men at $4.25 per day	25.50
80 tons egg coal at $3	240.00
	$322.50
New Equipment.	
3 firemen at $5 per day	$ 15.00
3 coal passers at $4.50 per day	13.50
3 ash men at $4.25 per day	12.75
79 tons screenings at $2.75	217.25
1 oiler at $5 per day	5.00
	$263.50
Saving per day	$ 59
Saving per year	21,535

Assuming an investment in new equipment of $100,000 it follows that:

Interest on investment at 6 per cent	$ 6,000
Depreciation at 4 per cent	4,000
Upkeep at 2 per cent	2,000
	$12,000

Deducting this $12,000 from the annual saving still leaves $9,535, or nearly 10 per cent above what might be considered a fair return on the money. The gain is more than could be obtained ordinarily on a safe investment.

A typical installation consists of a track hopper into which dump-bottom cars are unloaded. A short cross-conveyor is arranged to carry the coal from the track hopper into a crusher, which in turn discharges the coal into a bucket conveyor. The crusher is provided with a bypass around the rolls and into the main conveyor, to be used in case the coal does not require crushing. The main conveyor is arranged to convey the coal from the crusher and distribute it in overhead bunkers, from which it drops through spouts into the stoker hoppers. The bucket conveyor passes directly in front of the ash doors in the ash tunnel, and the ashes from the various ashpits are hoed directly into it to be conveyed up into the ash burner.

The secret of a successful installation is the providing of ample room for repairing and replacing broken or worn-out parts of the machinery. Permanent platforms and ladders providing easy access to the equipment are indispensable to proper maintenance.

With a uniform load the chain grate with natural draft is a desirable stoker for the bituminous coals mined in the Middle West. Where the load varies and peaks must be met, the chain-grate stoker with forced draft should give better results. One especially favorable feature in connection with the forced draft is that it makes the installation of an economizer possible. With natural draft only, unless an exceptionally high stack is available, the advantage of an economizer is doubtful.

Advantages of Superheaters and Economizers.—Superheaters are successful when they are located in a sufficiently hot zone of the setting. It is a mistake to assume that a superheater can take the place of an economizer. Sufficient heat head to cause the heat to flow into the stream does not exist in the cooler zones of the setting and breaching generally occupied by the economizer. The proper location for the superheater in horizontally baffled boilers is in the combustion chamber behind the bridge-wall, and not in the comparatively cool last pass or breaching. In vertically baffled boilers, the proper location is at the top of the first pass.

When it is considered that the specific heat of superheated steam is about 0.55, while that of the flue gases is 0.24, and that about 24 lb. of flue gases result per pound of coal burned, it is evident that the amount of heat actually absorbed by the steam due to its super-heat is comparatively small. Thus in a 350-HP. boiler using coal containing 11,500 B.t.u. per pound and operating at 60-per cent efficiency, the following results obtain:

Total steam per hour, lb.	10,500
B.t.u. absorbed by steam, due to its being superheated 100 deg.	577,500
Coal per hour, lb.	1,680
Total flue gas per hour, lb.	40,320
Reduction in temperature of flue gas, due to heat absorbed by steam, deg. F.	59

In comparison with an economizer the superheater, then, does not materially lower the gas temperature, and as often pointed out, the advantage of superheated steam over saturated steam is not due to the additional heat it contains, but to its improved properties.

Boiler Room Instruments.—The efficiency of a boiler and its furnace depends on five fundamental conditions: Proper draft, complete combustion, air-tight settings, clean heating surfaces and low flue temperatures.

In order for these conditions to obtain, the stack must be of the proper size and height, and the breeching must have proper area, be free from sharp bends and as short and direct as possible; the furnace and combustion chamber must be designed and built to suit the particular fuel to be burned; the brickwork or casing enclosing the boiler must be tight, free from cracks and air leaks, and the heating surfaces must be kept free from scale and soot.

The fundamental apparatus necessary to see that these conditions are maintained are: Draft gages connected over the fire and in the breeching, an Orsat apparatus, sufficient soot blowers and tube cleaners and pyrometers. It is the writer's opinion that the simpler the instrument equipment the better will be the results secured by their use.

A separate recording pyrometer in each boiler breeching is desirable. Nothing is more detrimental to economy than high flue temperatures. For instance, consider the 350-HP. boiler used to illustrate in the discussion of the superheated. There were 40,320 lb. of flue gases per hour. An increase of 50° in the temperature of these gases leaving the boiler means that 483,840 b.t.u. are wasted per hour. This is equivalent to 42 lb. of coal, or 2.5 per cent of the coal fired. In many plants flue temperatures are as much as 150° higher than necessary, which is an avoidable loss of 7.5 per cent. The continuous record given by the recording pyrometer is the best means of keeping check on this source of loss.

In many cases the hand Orsat is more desirable than the CO_2 recorder, when the engineer on watch is required to make gas analyses at least once an hour and is required to see that these analyses show reasonable percentages of CO_2. That is, if he makes an analysis and finds the CO_2 low, he must at once determine the cause, have it corrected and secure the normal analysis. In large plants operating 10 to 20 boilers, this is not practicable and the recording apparatus must be resorted to, with an expert devoting his entire time to the instruments in the boiler room.

The final evidence of boiler efficiency is, of course, the pounds of water evaporated per pound of coal fired, and no plant is complete that is not provided with a coal scale and feed-water meter. For uniform flow, such as is secured by centrifugal boiler-feed pumps, the venturi meter is the desirable boiler-feed meter. However, with reciprocating pumps some form of "V" notch meter is preferable, as there is some question as to the accuracy of the venturi meter under a pulsating flow. In water-works pumping stations where the feed water is supplied by a number of reciprocating pumps driven by the individual pumping engines, a fairly uniform flow is obtained and the venturi meter has been found satisfactory.

It is desirable that where more than one boiler is needed to carry the load, every unit be operated at least to its rated capacity. It often happens that one or two boilers carry most of the load, while the others are allowed to run light. Indicating steam-flow meters attached to each boiler nozzle are valuable, as they show exactly what each boiler is doing.

In laying out a boiler room it is essential that all gages and controlling apparatus be located in as convenient and accessible places as possible. The damper lever should be brought to the front of the boiler and arranged so that the fireman can keep his eye on the draft gage while regulating the damper. The draft gage, steam flow meter, steam-pressure gage and water columns should all be visible from the same point in front of the boiler.

Air Lift Pumping Plants*

By CHARLES J. DEEM,

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Some 15 years of experience have taught me that in many, many instances, wells are just as individual in their actions as are persons. Therefore, a properly designed air lift installation, operating satisfactorily in one well, might give entirely different results when installed in another well which to an experienced operator might seem to be identical with the first.

While experience is not absolutely essential to the pumping of water from deep wells by the means of compressed air, yet I know of no engineering field where experience counts for more or is more essential than in air lift pumping.

Some of our best engineers have branded air lift pumping as a system sadly lacking in economy, but in such cases their judgment has been based upon results obtained from improper methods of piping in connection with inefficient air compressors. Many have also become convinced that there is no special merit in the patented air lift pump, and believe that home-made devices will answer the purpose just as well. However, in all my years of experience, I have never yet seen one of these home-made lifts compared with which a patented pump would not give excellent returns on the small amount of money invested.

How the Air Lift Operates.—Contrary to a popular belief, the compressed air discharged through an air lift pump does not blow the column of water upward after the first discharge. When the static head is lifted from the working head of the well by the first inrush of air, the water is forced out of the pipe in a solid column. After that, the compressed air passing through the pump reduces the specific gravity of the water in the discharge line of the pump. This consequently moves upward by the expansion of the air bubbles, aided by the greater weight of the solid column of water, surrounding the discharge line. In an economically designed air pump, it is imperative that the formation of large bubbles of air be avoided, for these have a tendency to rush upward without lifting the proper amount of water for the stored energy that they contain. Therefore, the pump should divide the air into small streams or jets, creating as many small bubbles as possible in order to give the best economy. The slip of these bubbles constitutes the chief loss in the energy of the air lift. It is figured that this varies as the square root of the volume of the bubbles. Therefore, the smaller the bubbles, the more efficient the air lift.

Each Well an Individual Problem.—No one has yet been able to figure a master formula for the installation of the air lift. However, the manufacturers of air lift pumps have, at a great expense, gathered data from laboratory tests and field experience that enable them to construct formulas which cannot be universally applied to all conditions, yet they can define and introduce certain rules which enable them to calculate the requirements for an installation when the exact data are known.

When exact data are lacking, conditions are usually assumed and a lift installed. Then from results obtained, the engineer can, by basing his judgment on experience, proceed to pipe up the well so as to get economical results. To give an illustration of this: some years ago I installed an air lift in a flowing well on a ranch in Southwest Texas. The well was 8 in. in diameter, about 600 ft. deep and flowed about 20 gal. a minute. The owner of the ranch had only a small compressor, its maximum capacity being 30 cu. ft. of compressed air per minute. A 6-in. pump was installed, 2 ft. in the well, and this 30-ft. of air delivered to it. The head of the well dropped 20 ft. from the surface and the well yielded 530 gal. per minute, accurately measured over a knife-edged weir. Of course, this was phenomenal. Never before or since have I seen such a small volume of air deliver so much water from a deep well.

Recently at Fort Dodge, Ia., we installed a 6-in. pump in a flowing well, located in an island in the Des Moines River. The well was 8 in. in diameter, 500 ft. deep and flowed 21 gal. per minute. The same size pump was located 200 ft. from the surface and we delivered to it 200 cu. ft. of air. The working head of the well dropped 150 ft. from the surface and yielded 80 gal. per minute. As one can readily see, this proved to be a very uneconomical installation. Yet to all outward appearances, the conditions in the second well were the same as those in the first, and the results were not even comparable. It is in this second well that experience would have been necessary to have piped it up properly had the city decided to use it. However, they had plenty of other water available, so the well was abandoned. But an air lift could have been installed in it that, figuring from the current imput at the motor of the compressor to the water discharged in the reservoir, would have shown 30 per cent efficiency. This could have been obtained by installing a 3-in. air lift and taking 50 per cent submergence, or, in other words, by placing the lift as far below the working head of the well as we were going to lift the water. This would have yielded 1 gal. of water for 0.63 cu. ft. of air at 67 lb. pressure. Of course, the starting pressure in this well would have been greater than that of the other wells of the system, yet this could have been offset by the use of an auxiliary air line to lift the head of the well.

Some Advantages of Pumping with the Air Lift.—One reason why the air lift pump proves valuable, where the water contains much iron and sulphur, is that when a well is pumped by air the water undergoes aeration. The air and water are mixed under pressure and this tends to throw off the sulphur gas and precipitates a great deal of the iron. One of the principles on which the iron breaker works is aeration.

Many wells pump a great deal of sand and as the air lift has no moving parts in the well, grit has no effect upon it. Any number of wells may be pumped from a central plant and there is no limit to the quantity of water than can be handled. With a properly designed system the extra cost of pumping wells located a mile from the power plant is not material.

It has been stated that an air lift system requires little or no attention outside of keeping the compressor in proper running order. While this is practically true and cited as one of its advantages, yet sometimes it proves to be a disadvantage, because an installation will continue yielding water for years without giving any trouble. Yet there are times when the system becomes unbalanced, the working head of the wells recede, which changes the percentage of submergence, thereby reducing the yield of the well and increasing the amount of air required. So you can see that if the wells were checked up once or twice a year, and changes made to meet the new conditions, a great deal might be saved in operating cost.

Importance of Keeping the System Balanced.—Sometimes very little things cause a great loss in economy. Not long ago I was called to a plant where a battery of five wells was being pumped from one compressor. The compressor at its maximum speed was barely large enough to pump the amount of water required. The operator told me that when the plant was first installed it gave excellent results, but there had been a decided falling off in the yield of the wells. The system was well designed and should have given good results. Upon investigation, I found that two of the wells were much weaker than the other three, and that they operated at about 15 lb. less pressure than the other wells. When the engineer had balanced up the system, he had set the regulating valve at the well head of these two weaker wells so as to admit only enough air to pump the water that they would economically yield, and, of course, had left the valves wider open on the strong well. When starting the system pumping, the operator discovered that many times these two weak wells did not come in. Their static head being the same as the stronger wells, and being supplied with much less air they did not start so easily. In order to overcome this he had thoughtlessly taken a wrench and opened the valves of these two weaker wells. Of course, any force follows the line of least resistance, and the larger part of the volume of air, made by the compressor, rushed into the weaker wells from which it could not lift the same amount of water as it could have done from the stronger wells. Therefore, this system was out of balance and giving poor results, through no fault of the air lift or the man who installed it. When air lift systems are counted excessively costly to operate, I think it may safely be concluded that there is good cause for this, and that the chances are the troubles may be easily removed.

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*Abstract of a paper presented at the last annual meeting of the Iowa Section of the American Waterworks Association.

Selecting Proper Size of Pump.—A great many mistakes are made when installing air lifts, especially by novices in the business, in choosing the size of the pump to be used to deliver economically a certain volume of water. In order to make that as plain as possible, I will give a concrete example:

If we wanted to lift 150 gal. per minute from a well with a working head 80-ft. below the surface, the most economical pump to be installed would be a 3½-in. lift at 65 per cent submergence. Under these conditions, this pump should yield 1 gal. of water for every 0.3 cu. ft. of air at 67 lb. pressure. As one can easily figure, the pump would be located 229 ft. from the surface. Now suppose instead of being able to get 65 per cent submergence, we can get only 40 per cent submergence. In order to deliver 150 gal. per minute under these conditions, a 4½-in. pump should be used and one could expect 1 gal. of water for every 0.59 cu. ft. of air at 25 lb. pressure.

By a little figuring the engineer can ascertain that it required 1.1 more horse power to raise the water in the second instance than it did in the first.

As can be noted from this example, as the submergence decreases, the size of the discharge line should increase. But this is only a general rule and the conditions in the well to be pumped wholly govern the change to be made.

Outfall Sewer of Creosoted Wood Stave Pipe

A 60-in. creosoted wood stave outfall sewer has been completed recently for the city of Seattle, Wash. The section is 1,760 ft. in length and connects with a 78-in. concrete sewer in Rainier Ave. The staves in the pipe are 2½ in. in thickness and made of selected fir. They are bound with bands ½ in. in diameter. There are two separate pieces to each band, the ends being connected by means of malleable iron shoes which are spaced 6 in. apart. The lumber was creosoted by the pressure and vacuum process. By this method creosote was forced into the wood through pressure and after thoroughly saturating was extracted through vacuum, the wood retaining 8 lb. of creosote to the cubic foot. This wood stave pipe sewer was installed by the Continental Pipe Mfg. Co., of Seattle, under a subcontract from the Puget Sound Bridge & Dredge Co., the general contractors for the Rainier Ave. sewer work.

60-In. Creosoted Wood Stave Outfall Sewer.

Results of National Irrigation

An interesting summary of the work accomplished by the U. S. Reclamation Service since its organization was given by Mr. Arthur P. Davis, Director and Chief Engineer in the December Reclamation Record, from which the notes following are taken:

Since 1902 the Reclamation Service has constructed the irrigation system to completely supply 1,780,000 acres of land. Also the capacious storage reservoirs of the Government are furnishing a supplemental supply of stored water to 1,000,000 additional acres in other projects, or a grand total of 2,780,000 acres.

On the Government project lands are 40,000 families in independent homes. The population in cities, towns, and villages in these Government projects has been increased by an equal number of families. That is to say, on the 1,780,000 acres reclaimed there are now profitably employed and satisfactorily housed 400,000 people.

Since the first Government ditch began turning its waters upon the land in 1905 the crops produced on the reclaimed lands have had a total value of more than $250,000,000. The present annual crop returns are now more than $70,000,000, not including the value of crops grown on the 1,000,000 acres outside of projects which are supplied with stored water.

In 1902, the beginning of Government irrigation, the average value of the desert lands in the projects did not exceed $10 per acre. The total value, therefore, of the 1,780,000 acres in Government projects did not exceed $17,800,000. Government irrigation has increased the value of the project lands $200 per acre, or a total of $356,000,000. It has increased the value of the 1,000,000 acres in other projects by $100 per acre, or $100,000,000. The increase in the value of land in the cities, towns, and villages within projects is easily $100,000,000, or a total increase in land values of $556,000,000, due to this work.

In connection with the above summary no consideration has been given to 1,138,000 acres of land included in Government projects which will be irrigated when the engineering works are completed, the present market price of which has increased at least $50 per acre by reason of this fact.

The increase in the price received for state lands included in the projects and now mostly disposed of was at least $3,000,000 of direct revenue derived by the states.

Dividing the acreage reclaimed—1,780,000—into the net cost of the works of $122,645,000, we have a cost of approximately $69 per acre for the lands in reclamation projects to which the Government can now deliver water. This cost, however, includes the cost of serving stored water to about 1,000,000 acres of land under the Warren Act. If these lands be included, the average expenditure per acre benefited is less than $45 per acre, and this cost includes large storage works and canals useful for future reclamation on projects now being completed, the utilization of which will further reduce these figures of cost.

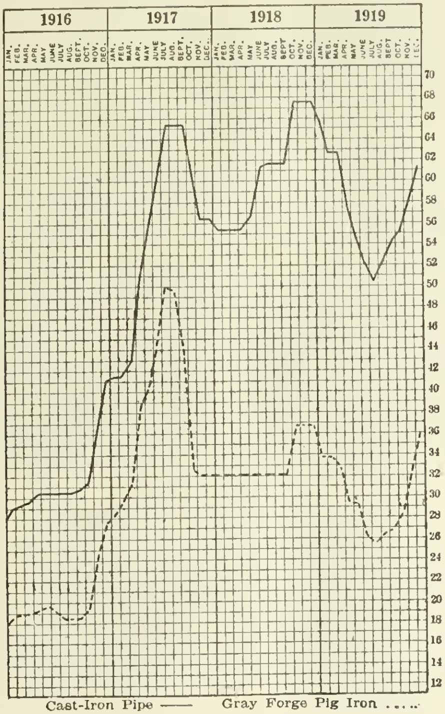
Up to the end of June, 1919, there had been diverted from the United States Treasury and made available for reclamation purposes the sum of $119,882,084. Of this amount there was cash on hand June 30, $1,008,502. Out of the funds thus made available, investigations have been made of proposed projects which have never been approved for construction, requiring an expenditure of $1,207,954. This leaves a reimbursable investment in irrigation works of $117,665,627.

The net cost of constructed projects to June 30, 1919, was $122,645,000. It is estimated it will be necessary to expend $49,353,000 in addition in order to bring the entire investment into a position where construction charges may be collected. Thus the total ultimate cost of present project units is computed at $171,998,000.

To return this cost contracts for specific amounts aggregating $63,535,000 have been executed by individuals and irrigation districts and are secured by liens on the irrigated lands. In addition there are other contracts for leases of land, power sales, etc., valued at $6,724,000. On a number of projects and units of projects public notices announcing the construction charges have not been made, and the security for the return of the construction cost for these areas and areas of public land not yet entered under the provisions of the reclamation law is valued at $96,659,000. The last figure is secured by general contracts with water users' associations and irrigation districts executed prior to commencement of construction, pledging the land benefited to return the cost of the works. For the works at present under construction the total ultimate return is estimated at $166,918,000. From the above it will be seen that the amount which may not be returned in connection with the constructed projects is only $5,080,000. If we add to this the deficit in the operating account to June 30 ($1,036,000), we arrive at a total deficit of $6,116,000. This is about 5.2 per cent of the amount invested in constructed projects, or 3.5 per cent of the total ultimate cost. It is probable that a portion of the deficit in the operating account will be returned by the increase of operation and maintenance charges for future years, so that the actual deficit upon completion of all units and projects which have been constructed and operated may be less than the figure given above.

Cast Iron Pipe Prices—1903-1919

The accompanying diagrams reproduced from The Iron Age of Jan. 1, 1920, show the course of prices for the past 17 years on 6-in. cast iron water pipes, f. o. b. New York, in carload lots, per ton of 2,000 lb. The prices for the past four years have been plotted on a larger scale to show in fuller detail the great increase in cost resulting from war conditions. The prices for the first 7 years were furnished by Daniel Runkle, at that time with the Warren Foundry & Machine Co., 11 Broadway, New York, and for the remainder of the period covered were averaged from weekly quotations in The Iron Age.



Price Course of Cast Iron Pipe and Gray Forge Iron for 1916-1919.

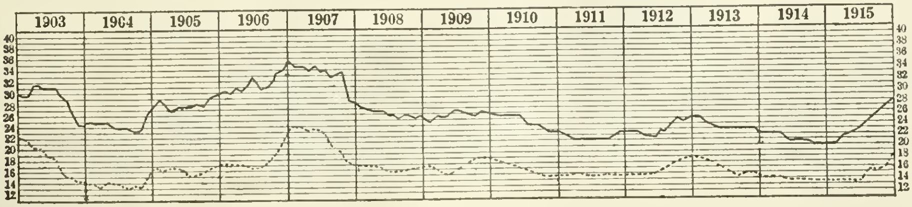
To show how closely cast-iron pipe prices follow the fluctuations in pig iron a curve has been added giving the course of prices at Philadelphia and vicinity on gray forge pig iron, which is largely used in making pipe. These prices, on which this curve is constructed, have been averaged from weekly prices in The Iron Age.

Collapse of 14 Ft. Sewer in Philadelphia

Interesting particulars regarding the collapse of a 76-ft. length of 14-ft. sewer in Courtland St., Philadelphia, are given in the recently issued report of the Bureau of Surveys for the year ending Dec. 31, 1918. The sewer failed on Aug. 12, during the heaviest recorded rainfall in the history of the city. At the time of the failure of the sewer, a large touring automobile, standing along the north curb of Courtland St., was carried down with the street paving and was deposited in the side of the break near the water's edge. Courtland St. at this point is built up. The buildings front on Thirteenth St. and on York Road, with their gable ends extending along both sides of Courtland St. As the break in the street endangered the abutting properties, steps were taken to immediately shore up and secure the trench and remove the automobile. Before this could be accomplished, a storm during the night of Aug. 14, carried the automobile into the sewer and up to the time of writing the report no trace of it had been found.

A large force of laborers was put on the work as rapidly as the men could be obtained and by Aug. 29 the trench was sheathed and shored, except for the bottom sets of shores, which were ready to put in place. On the afternoon of Aug. 29, another unusually heavy storm caused a further collapse of the sewer for a length of 60 ft., making a break in the street for a total length of 136 ft. and a width varying between the width between curb lines and the house lines of the street. The new break required the reshoring of the whole trench and the use of longer and heavier timbers, which increased the cost of the repairs very considerably above previous estimates. The increased width of the break increased the danger to the buildings, as their foundations were supported on filled ground and treacherous clay. As their collapse was imminent, a day and night force was immediately employed and continued until the trench was securely shored and sheated for its entire length. The work was carried on under most trying conditions. Wages were increased to rates beyond anything known before, and materials advanced in price 200 and 300 per cent. These factors, together with the scarcity and the decreased efficiency of labor of 50 per cent or more, caused the work to proceed slowly and the cost to increase beyond any reasonable expectations. The Government's policy in establishing an eight-hour day with payment of time and half-time for overtime and double time for Sunday compelled its adoption on this work. Labor, while demanding an 8-hour day, insisted on working 10 hours in order to secure 11 hours pay. This condition made it impossible to divide the work into three shifts of eight hours each, making it necessary to pay for 14 hours for 12 hours' work. The lowest rate of pay for laborers was 50 ct. an hour. Bottom men were paid 60 ct. an hour, timber men 70 ct. an hour, and engine men 95.5 ct. an hour. Sand and gravel cost $3.25 a ton, and pebbles $2.85 a ton. Timber ranged in price from $59 per M. ft. B. M. for 3-in. plank to $120 per M. for the 14-in. x 14-in. long pieces used to support the derricks.

When excavation was carried to the depth of the sewer in-



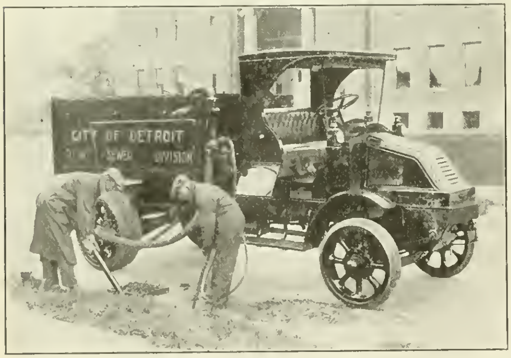
Price Course of Cast Iron Pipe at New York and Gray Forge Iron at Philadelphia During the Period 1903-1915. Pipe Prices Are Indicated by the Heavy Black Line; Pig Iron Prices by the Dotted Line.

vert, it was discovered that, through successive floods, the underlying soil had been cut out to a depth of from 6 to 8 ft. and in order to secure a proper foundation it was necessary to extend the excavation to that depth and build up with concrete masonry. This additional depth added to the difficulty and cost of the work. The sewer for the entire length of the break has now been reconstructed with a heavy brick arch and concrete cradle lined with granite block, supported on a concrete base laid on a soil of sufficient bearing value for the loads required to be supported. The last arch was completed Dec. 24, 1918, and the refilling of the trench, which was commenced as soon as work permitted, was continued with an increased force.

A further examination was made of the Wingohocking sewer and its tributary branches early in the month of September, and it was found that at the intersection of 15th St. and Belfield Ave., the 13-ft. diameter section was broken for a length of about 35 ft. The supporting cradle and invert of the sewer were entirely gone and the arch, while intact, was in danger of collapse.

Catch Basin Cleaning Machine

The Public Works Department of Detroit, Mich., has recently placed in service a portable pumping apparatus especially designed for cleaning sewer catch basins, gulleys and other indenture. With this equipment the contents of the catch basins are pumped directly into a large water-tight tank on a truck. The machine requires two men for its operation and is claimed to do as much work in one day as would be accomplished in three or four days by the hand method of cleaning. In addition the cleaning is done in a sanitary manner and the necessity for piles of filth on the street, so common under the old hand-cleaning method, is obviated. The equipment described above was obtained from the Springfield Engineering Co., Springfield, Ohio. It consists of a Seco portable pumping apparatus, manufactured by the above-mentioned firm, mounted on a Springfield-Kelly 5-ton truck.



Catch Basin Cleaning Outfit.

News Letter

St. Louis Items

L. J. Smith, president of the L. J. Smith Construction Co., Kansas City, who has been under the weather for a while, is up and around again. Was with us a day last week. Nothing new.

Plans for extensive improvements between Council Bluffs and Brunswick are being made by the Wabash R. R., to take effect when the railroads are back in private control after March 1. Brunswick is a junction point on the main line from Kansas City. Improvements on the track ballast will be made, and heavier steel rails will be laid in both the yards and on the main line.

Ira J. Printy has moved a small steam shovel onto his grading job in Granite City, Ill. Printy came over one day last week looking for ten more patent dump wagons for this work.

D. C. Bowman has resigned as division engineer of the Wabash St. Louis Terminals and has accepted the post of vice-president and engineer of the Industrial Track Construction Co. of St. Louis. Bowman is a graduate of Penn State University and started railroading with the Wabash in 1911. He was detailed on construction work upon the new union station in Kansas City and later served at Moberly, thence coming to St. Louis.

L. P. Robbin reports his 8-team, wheeler, Fresno and slip outfit idle at Litchfield, Ill.

The John Marsch Co., Inc., Chicago, have started on four miles of the new Indian Lake road north of the National Stock Yards, Ill. Nick Nerenhouse is superintendent and L. A. Braskey is office man on the job.

Harry S. Kramer, president of the East Side Levee and Sanitary District, East St. Louis, Ill., who has just been re-elected, has announced that the two projects proposed by the board are: An intercepting canal which will run along the base of the bluffs and carry off the water which now spreads over the drained area, and the diversion of the Cahokia Creek at a point north of Black bridge to the river. The cost of the improvements will be about $2,000,000 each. In the latter the railroads, the stockyards and the levee board are to share.

D. C. Gahan finished his state road contract near Springfield, Ill., and has his outfit hauling shale for the Oak Ridge Cemetery there. Will start on a new levee job near the St. John Hospital, Springfield, as soon as the frost is out of the ground in the spring.

While in Kansas City the other day the writer met John Burke, who has been out of the contracting business for a number of years. John informed him he is getting tired of farming and going to break back into the contracting game this spring. Success to you, old boy.

J. L. Simmons writes us from LaPlata, Mo., that he has a 10-team, wheeler and scraper outfit idle there.

J. W. McMurray of Kansas City spent a couple of days with us last week. Mack is working on a big job of grading and putting in foundations for the new Kansas City Bolt & Nut plant in Kansas City, Mo.

C. S. Jones has moved his station outfit from North Illinois onto a new job on the M., K. & T. R. R. in Oklahoma.

On account of the cold weather Stresenreuter-Cotton & Co. have shut down temporarily on their state road work in Illinois.

Contractors when in want of work or labor for their outfits write Koenig's Labor Agency, 612 Walnut street, St. Louis, Mo., 503 Delaware street, Kansas City, Mo., or 509 S. Thirteenth street, Omaha, Nebr.

Personals

George F. Winn has been appointed city engineer of Nashua, N. H.

Daniel Miller has been appointed borough engineer of Bangor, Pa.

Herbert C. Dilliard has been appointed borough engineer of Nazareth, Pa.

C. H. Koyl has been appointed engineer of water service of the Chicago, Milwaukee & St. Paul R. R.

Edward Braunberns, assistant city engineer of Warren, O., has been appointed director of public service.

Thomas B. Wyman, formerly mayor of Munising, Mich., has been appointed city manager of Painesville, O., at $4,000 per year.

A. W. McDonald of Austin, Tex., has been appointed secretary of the Texas state board of water engineers to fill the vacancy caused by the death of James Hayes Quarles.

I. G. Monroe has been appointed superintendent of streets and sewers of Youngstown, O., succeeding Joseph Vogelberger, who resigned to re-enter the general contracting business.

Col. Walter Fry, formerly sanitary officer at Camp Funston and for the past six months health officer for Junction City and Geary County, Kansas, has resigned to accept a similar position at Lincoln, Neb. He will be succeeded by Dr. C. F. Kinnemann of Keokuk, Ia.

Oliver T. Reedy, for 17 years engineer on design and construction with the U. S. Reclamation Service, has opened an office at 418 Century Bldg., Denver, Colo., for service as consulting engineer. He will specialize in irrigation, drainage, water supply, dams, tunnels, reinforced concrete, investigations, reports and designs.

Harold L. Tillson has been appointed district engineer in charge of Portland Cement Association activities in Iowa, with offices in the Hubbell Bldg., Des Moines, Ia. Mr. Tillson has been connected with the Portland Cement Association for more than three years and since December, 1917, has been identified with association work in Iowa.

William R. Conrad and J. Stewart Buzby, who for a number of years has been actively associated with Mr. Conrad as principal assistant, have formed a partnership for the continuation of the business of inspection and tests of materials, with especial relation to water and gas works supplies, and of reports, specifications, designs and general engineering.

Industrial Notes

The John F. Byers Machine Co., Ravenna, O., announces the opening of its new Chicago district office, 20 West Jackson Blvd., Chicago, in charge of E. L. Kelzer.

The Ideal Engine Co., Lansing, Mich., manufacturer of gasoline engines, hoists, pumps and contractors' equipment, and the Ideal Power Lawn Mower Co., manufacturer of power lawn mowers, have opened branch office and salesrooms at 533 S. Dearborn St., Chicago, Ill., under the management of E. H. Peters.

Mr. Ben Haislip, who for the past four years has been connected with the Chicago office of the U. S. Rubber Co. as sales engineer, has joined the sales organization of the Traylor Engineering & Mfg. Co. of Allentown, Pa. Mr. Haislip, who from 1904 to 1905 was with the Allis-Chalmers Co. and from 1905 to 1916 with the Power & Mining Machinery Co., will be connected with the Chicago district office, 1414 Fisher Bldg., of the Traylor Co. in the capacity of sales engineer and assistant to L. J. Hewes, district manager.

Obituaries

John R. Holmes, director of public safety of Cincinnati, O., died Jan. 5, aged 63.

Fred A. Little, construction engineer of the Idaho Power Co., died Jan. 1, in Boise, Idaho.

C. A. Anderson, a railroad contractor formerly of Ishpeming, Mich., died Jan. 5 in Portland, Ore., aged 92.

William J. Gannon, superintendent of streets of Fitchburg, Mass., and president of the Massachusetts Highway Association, died Jan. 5 at his home in Fitchburg, Mass., aged 52.

Sir John Jackson, an English contractor, died Dec. 15 in London, England, aged 68. He was a civil engineer of note. Among the great projects in which he aided were the Manchester ship canal, the railway across the Andes from Africa on the Pacific Coast to La Paz, Bolivia, the great barrage across the Euphrates River near Babylon, the Mesopotamia irrigation works and harbor work in Canada, South Africa, Singapore and other places.

Railway and Excavation Monthly Issue

ENGINEERING AND CONTRACTING

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The four rotated special monthly issues and 4 quarterly issues of E. & C. (52 in all) entirely cover the civil engineering and contracting field at $3.00 a year. The special quarterly issues relate entirely to foreign engineering and construction practice. The *articles* in the first two issues of each month completely cover the municipal engineering and contracting field. The *articles* in the first and fourth issues of each month completely cover county engineering and highway engineering and contracting. The *articles* in the 3rd and 4th issues of each month completely cover steam and electric railway location, design and construction. See the "masthead" on the first page of the Weekly News Section for information about our weekly contract news.

Roads and Streets—1st Wednesday
(a) Roads
(b) Streets
(c) Street Cleaning
(d) Municipal Miscellanies
(e) Management and Office System

Waterworks and Hydraulics—2nd Wednesday
(a) Waterworks
(b) Sewers and Sanitation
(c) Irrigation and Drainage
(d) Power and Pumping
(e) Management and Office System

Railways and Excavation—3rd Wednesday
(a) Excavation and Dredging
(b) Rivers and Canals
(c) Quarries and Pits
(d) Railways, Steam and Electric
(e) Management and Office System

Buildings and Structures—4th Wednesday
(a) Buildings
(b) Bridges
(c) Harbor Structures
(d) Miscellaneous Structures
(e) Properties of Materials
(f) Management and Office System

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E. & C. Index Furnished Only on Request

The Index for Vol. LII—July-December, 1919—issues of Engineering and Contracting is now being prepared. In common with many other publishers we have adopted the practice of sending the index to only such subscribers as request it. Therefore, if you want the index for the last 6 months you should notify us at once. Those who requested the index for the previous volumes have been listed and need not notify us again.

"Breaking the Vicious Circle" May Break the Railways.

It is estimated that the 60,000,000 people living in American cities are spending more than $10 per capita per annum to see the "movies," and that they are paying 80 per cent more per ticket than in 1914. Yet when these same people are asked to grant the street railways a 20 to 40 per cent increase over the old 5-ct. fare a loud protest is heard, and the traction owners are accused of extortion.

American newspapers are largely to blame for this attitude of the public toward public utilities. In the past the newspapers have seldom defended the public utility companies from unjust accusations. Even at present editorials supporting increases in public utility rates are relatively scarce. Naturally politicians seek to please the public by opposing all rate increases. They do this in advance of investigations to determine the justice of requests for higher rates, acting, we suppose, on the principle that there can never be any justice in raising such rates.

When all other arguments against increasing the rates of utility companies are proved to be fallacious, two remain—one venerable even if vulnerable; the other novel even if more ingenious than convincing.

The first of these arguments is really not an argument but a bare assertion, namely that the stock of the public utility company seeking higher rates is "watered." It matters not that an appraisal of physical property shows this statement to be false, politicians like Mayor Thompson of Chicago, continue declaiming their undying opposition to paying any higher dividends on watered stock.

The second argument—the novel one—takes this form: President Wilson has called upon labor and capital alike to break the "vicious circle of rising prices." Let us heed the call, and begin by denying higher rates to all public utilities. Moreover, have not eminent political economists predicted a general fall in prices? Let us not be hasty in raising utility rates when price levels are likely to recede.

Yet the very people that use this argument have either received substantial increases in

28 Pages=40 pages

The 28 pages of articles in Engineering and Contracting contain as many words as 40 pages of the size and typography commonly used by other engineering periodicals. Ours is the same size of type and type-page as that of The Literary Digest—easily read, yet giving a large volume of reading matter per page. Our 28 pages of articles would fill 112 pages of the standard 6x9 in. text-book. It would take 10 such books of 580 pages each to hold all the articles printed each year in Engineering and Contracting, to say nothing of our weekly construction news.

their own income or are engaged in violent effort to secure an increase. The "vicious circle" is to be so drawn as to include you and me in its elastic periphery, but to exclude the public utility companies.

As to the forecast of a few economists that prices are about to fall, little is said about the predicted extent of the drop, and nothing at all about the prediction of a greater number of economists that no marked decrease in prices can be expected for many years.

Very soon the steam railways will ask the Intertsate Commerce Commission for a 25 per cent increase in freight rates. Coincidently Clifford Thorne and the other professional opponents of the railways may be counted upon to intone with one voice:

Break, break, break, we pray thee, I. C. C.,
This vicious circle, break for all eternity.

The Imminent Battle Over Theories of Valuation.

It is estimated that the appraisals of all the principal railway systems will be completed two years hence. The great task of inventorying these properties is drawing to a close, but after the engineers and accountants have finished their reports several years may elapse before the supreme court will have decided all disputed points. Certain it is that there will be litigation that will involve all the basic theories of valuation. The doubling of construction costs during the past five years has alone served to create many a dispute as to the unit prices to be used in the valuation of railways and other public utilities.

The decisions of the supreme court uphold the theory of reproduction cost at present prices. But state public service commissions have usually favored the theory of reproduction under the conditions that existed at the time of construction including the unit prices that then existed, or an approximation thereto. In short, the state commissions have favored "the agency theory."

The agency theory has, however, several aspects. According to one of these, it leads to a valuation that is practically the same as the actual cost of the property. But by pressing the agency theory to its logical conclusion an entirely different valuation results, namely, the actual cost of the property multiplied by a price correction factor. Thus, if the general price level has risen 80 per cent since a given railway was built, its actual cost would be multiplied by 1.8 to get a value for rate making purposes. This theory assumes that the owners of the railway are entitled to have a fair return on their investment, measured in the purchasing power of that "return" and not merely in dollars. As we see it, there is no escape from the logic and justice of such an interpretation of the agency theory. Hence those state commissioners that have sought to keep down the values of public utilities by applying the agency theory, will find themselves confronted with a new phase of that theory, a phase that has suddenly come into prominence as a result of the recent leap in prices of all sorts.

C. A. Prouty, Director of the Bureau of Valuation of the Interstate Commerce Commission, recently said:

> It is, therefore, my hope that by Dec. 31, 1921, we shall have ready for the commission reports upon all principal carriers from the three sections and, if so, the commission will be in position to at once fix a tentative valuation upon all these properties. It is my belief that the tentative valuation so fixed would be found to be substantially correct, although it might in some slight degree be modified upon hearing of the objections of the carriers.

In saying that he believes that the tentative valuation made by his Bureau will be found to be substantially correct, Mr. Prouty refers to the findings of the Interstate Commerce Commission. What the supreme court will rule as to those findings is another matter. Unless the court reverses itself, one thing is certain: No valuation based solely on pre-war prices will be acceptable to the court.

For about 15 years, many engineers and attorneys have been training for the great battle that will soon begin—the battle of valuation theories. The initial struggle has already begun in the hearings held by Mr. Prouty. But the fight will reach its climax when the Supreme Court of the United States, for the first time in its existence, reviews the testimony of a great array of talented engineers and lawyers who have given years to the study of every phase of the problems of valuation.

The Low Salary Disease and a Suggested Cure.

"Knowledge is power," says the slogan, but it depends on what kind of knowledge and what kind of power is meant. A high school teacher has a considerable amount of knowledge, as a rule, and the power for good or evil that he exercises over his students is by no means small. His power to get an adequate salary—well that is another matter.

In five middle western states the average annual salary of a high school teacher is $1,100, as compared with $1,200 for a union hod carrier, or $1,900 for a union brick layer in Chicago. Small wonder that teachers are joining the American Federation of Labor. Yet the theory upon which that organization acts is that employers restrict wages in order to enjoy greater profits and that the main object of labor unions is to make employers relinquish part of their profits in the form of higher wages. Apparently that theory does not apply to a government and its employes, for governments are not profit making organizations. What, then, is the reason why cities underpay school teachers, for example?

An answer to this question goes to the very root of our system of representative government. The employes of a city or state are usually not paid either according to individual merit or according to any scale of wages that exists in private industries. The public officials who have the power to regulate salaries and wages are influenced mainly by the effect that their action will have upon voters. It is difficult to imagine a more irrational method of deciding what salaries and wages should be. Yet what organized effort is being made to change this fundamental defect? None that we know of. Protests there are against present compensation of public employes and the protests are both loud and numerous. But as well hope to prevent malaria by dosing with quinine as to hope for relief from the low-salary disease by protests. A sanitary engineer would stop malaria by draining the swamps where malarial mosquitoes breed. A political engineer could, in similar manner, prevent the recurrent salary disease. To do so he would first seek to put it beyond the power of elective officials to fix or regulate salaries and wages. An honest city councilman is usually so anxious to secure re-election that he prefers to work an injustice to many city employes rather than excite the adverse comment of newspapers by increasing taxes. In addition, the average councilman is not a skilled judge of the real worth of brain workers of any class aside, perhaps, from the class to which he himself belongs. The public in general is an even poorer judge of such matters. Logically, then, the task of determining the salary rates of municipal employes should be assigned to an appointed board of men experienced in rating human values. The findings of such a board should not be subject to veto by the city council or the mayor.

Since the majority of civil engineers are in the employ of the public, it would be well if they were to affiliate with other professional men, like the teachers, in an effort to secure changes in the law that will lead to a permanent cure of the low-salary disease. Indeed, it might be well were engineering societies to concentrate on this one effort, holding in abeyance nearly all other propaganda of a public nature.

Some Electric Railway Facts.

The gross annual revenue of the electric railways of this country is about $10 per capita, but practically all of it comes from city residents. Since city residents constitute about 40 per cent of the population they pay about $25 per capita per annum for street car transportation. This is not much more than double what they expend to see moving pictures. The electric railways are capitalized for about 5.5 billion dollars, but, deducting their investments in securities not representing electric railway property, their net capitalization is about 5 billion dollars, or $111,000 per mile of track. Of this capitalization about 60 per cent is bonds. The capitalization of the electric railways is about one-quarter that of the steam railways. There are about 9 times as many miles of steam railway track as of electric railway track.

If the residents of American cities were to buy all the stocks and bonds of all the electric railways at par, they would have to raise about $100 per capita to make the purchase, or a little more than twice what they have invested in municipal waterworks, or about as much as they have invested in waterworks and sewers combined.

It is difficult to see wherein such a purchase would benefit the average city resident, were he to put up his share of the purchase price. If he were not to put up his share, then he would continue to pay interest on the money loaned by other men to make good his failure to carry his share of the investment, and in that case he would be doing exactly what he is now doing under private ownership.

Any exponent of municipal ownership who honestly believes that it would be to his personal advantage to be a joint owner of the street railway that serves him, need only go into the open market and buy one share of its stock to enjoy that advantage.

Public Utility Rates and Bond Holders

To the Editor: In the Nov. 19, 1919, issue of Engineering and Contracting, you republished an article on "Two Conflicting Theories on Valuations of Railways and Utilities." In your addenda to this article as republished you apparently conclude that in order that full justice might be done to the public utilities, their rates should be increased in proportion to the increase in other commodities and services or at least in proportion to the increase in price of equipment, supplies and labor purchased by these companies. Mr. Cecil F. Elmes, of Sanderson & Portor, recently published an article in which he argues that the public utilities are most certainly entitled to as great an increase in rates for their service as other classes of business are entitled to, or at least are taking for their products, and that if such increase is not given the utility owners are losing large sums because the purchasing price of their dollar is only about half what it was several years ago.

We have a rate case coming up very shortly, and I have been giving this subject considerable consideration. The greater part of the property of most public utilities has been built on borrowed money, this money is secured under long-term agreement, by the sale of long-term bonds, or debentures or the sale of stocks having a fixed rate of interest. It is probable that considerably in excess of 75 per cent of the money invested in such utilities, is borrowed money, for which the terms of interest, security, and repayment are fixed by contract. This money was borrowed at low rates of interest and even today money may be had at a comparatively small increase in interest rates over that of five years ago.

If any utility whose property was constructed during prewar times and which was financed in the usual way, with say 10 per cent put up by the stockholders, 10 per cent or 15 per cent from earnings, depreciation, reserve, etc., and the remainder of the money borrowed on long-term securities, probably 40 or 50 year bonds, were to be given an increase in rates based on the present value of the property measured by reproduction today, it is probable that its return would be about double. Either this return must go to the stockholders or some arrangements must be made whereby the bondholders, who are the real sufferers under the present conditions, would receive a rate of interest of about twice that provided in the contract under which the bonds were originally issued.

No regulatory body would be willing to allow the stockholder such an enormous increase in profits. Increasing the rate of interest on bonds now issued would hardly be considered by the stockholders of any utility.

In the case of utilities, such as our electric utilities in this section which are being forced to expand and develop very rapidly in spite of the present high prices, it seems probable that before very many years the average investment per unit of capacity is going to be very materially increased. If rates are fixed on the investment basis at the present time and the future ratio of operating expenses to earnings cannot be materially decreased the companies will find themselves in a position of having their rate of return quite materially reduced unless rates are fixed high enough to take care of a reasonable increase in investment per unit of capacity or are increased from time to time as this investment increases. It seems to be generally agreed that the present level of prices will continue for a considerable time in the future, probably for many years.

Fresno, Cal. G. R. KENNY.

Waterproofing Railroad Structures

To the Editor: In your issue of Dec. 17 there is a review of a paper on waterproofing which was read by Mr. Joseph Ross before the Municipal Engineers of New York. I have not read Mr. Ross' paper, but if your digest of it expresses its contents accurately, as there is every reason to suppose it does, Mr. Ross has gone somewhat afield both on the premises which are the foundation of his argument and in some of his conclusions. In view of the great importance of the subject to the engineering profession, I trust I may be pardoned if I deem justifiable a somewhat extensive discussion of the principal points raised in this paper.

Mr. Ross quite properly condemns a felt membrane because it lacks both tensile strength and stretch. There is, however, one important feature of this type of membrane which he neglects. That is that most of the waterproofing felts absorb water, become water-logged and rot. I have seen, taken from the old New York subway at 149th St. and Broadway, a piece of felt waterproofing so thoroughly saturated with water that on squeezing it in the hand water ran out as if from a sponge. I have seen, also in the old subway, a section of felt waterproofing which was apparently sound, judging from the condition of the final swabbing, but which investigation proved to be entirely gone. Water, having made its entrance at some point where the swabbing was not thorough, had been drawn by the capillary attraction in the felt, through it for a considerable distance, rotting where it touched.

It seems somewhat incongruous that in a paper on waterproofing railroad structures, the categorical statement should be made that a cotton cloth membrane is too expensive for its relative efficiency since the greater number of railroads east of the Mississippi are using a cotton cloth membrane and are not finding it too expensive. Among the railroads that consistently use this type of membrane might be mentioned the New York Central R. R., Pennsylvania Lines, the B. & O., D., L. & W., Erie, Central of New Jersey, Philadelphia & Reading, Long Island, C. B. & Q., C. & N. W., C. & A., Chicago Union Station Co., and Indianapolis Union. A large part of the Boston subways were similarly waterproofed.

The jute membrane which was used throughout the New York subways has no place in a serious discussion of waterproofing. It has been proven to be the most fragile of all waterproofing membranes, it deteriorates very rapidly even through atmospheric moisture, and the rate of deterioration rapidly increases with the alkali content of the water. It is illogical first to put in a waterproofing system a material against which water acts so disastrously, and second to place on a concrete (which is an alkali surface) a material which the alkali will destroy. The entire inadequacy of jute or burlap, coupled with the frequent failure of waterproofing built up with it, has led to its very general rejection by the engineering profession. Its cheapness alone recommends it, but when we realize that waterproofing is one of the most expensive elements in all construction work to repair, we also recognize the fact that it is a fraud perpetrated on the owner to install a waterproofing only because it is cheap with no regard to its efficiency. The question of price, moreover, is misleading. The difference in price per square foot between any two recognized and accepted types of waterproofing is not more than from 3 to 4 ct. and the relation between this difference and the cost of the structure—no matter what the structure may be, is so small as to be negligible.

While felt is condemned in Mr. Ross' paper because of its lack of strength and stretch, and jute is condemned because it requires 100 per cent workmanship, the conclusion is reached, somewhat illogically it would seem, that the ideal waterproofing blanket would be one made up of these two products or with cotton replacing the jute. If jute is added to the felt, strength is attained it is true; but does the use of felt with jute make the jute any more simple to apply or cure the defects in the material itself? Or does the use of jute with felt add elasticity to the felt? While cotton is not open to any of the objections which have been raised to jute, it can add nothing to the felt but strength. Although a proper cotton membrane is quite elastic, its use can add no elasticity to the felt any more than if we imprison a rubber bands between two layers of paper we add elasticity to the paper. Rather, if we consider the parts as one whole as they are in a waterproofing blanket we have destroyed the elasticity of the rubber since it cannot function until the surrounding media has been ruptured.

The idea of the use of a wire mesh instead of the usual type of membrane is based on the theory that the membrane in a waterproofing course performs the same function as it would in concrete. This theory is not at all accurate. The waterproofing membrane performs two functions. It permits the piling up of a thick bed of the plying cement (which is the real waterproofing) and it holds this cement in place—makes it stay put. If, for example, the floor of a deep basement, or subway, or of a bridge should crack, as such floors often do, the membrane, yielding to the crack holds the cement fast and prevents it from being forced by water-pressure or otherwise through the crack and out. No wire mesh could take care of such a condition. I have tried this method of waterproofing on a small tank with rather disastrous results as I found it impossible because of the "spring" in the mesh to keep it imbedded in the asphalt I was using. Others, too, have tried it with the same result. It does give considerable strength to the waterproofing. But such strength is unnecessary. It gives no more elasticity than cotton. It is almost as expensive as two layers of cotton while the cost of application, particularly if we have to dope the plying cement with asbestos fibre (at $100 per ton), will be at least twice as great.

In regard to the use of any sheet metal, whether iron or lead, it might be said at the outset that it would be so vastly more expensive than any known form of membrane system as to be completely out of the question. Mr. Ross complains of the cost of cotton membrane waterproofing on the one hand and proposes on the other to use a vastly more expensive system. It might further be said, with regard to iron that if this material be used for waterproofing, it in turn must be waterproofed to prevent it from corrosion or rot, which immediately creates the rather anomalous situation of waterproofing your waterproofing. A further fact in regard to these materials is their inapplicability to concrete because of the different coefficient of expansion.

Bordering the terrace of the Capitol at Washington, there are a number of plant cases about 2½ ft. deep, 4 ft. wide and 10 or 12 ft. long. These plant cases were waterproofed with sheet lead, fastened, of course, around the top and locked together by crimping where the joints met. The difference in expansion between the concrete and the lead had ripped this waterproofing squarely in half, so that when it was exposed, it was found that the edges were nearly an inch apart.

In regard to brick in mastic, this has never proved satisfactory for two reasons. The brick is full of air and when there is embedded in it hot mastic the air is expanded, filling the mastic with blow holes or air pockets which eventually break, leaving room for the passage of water. Moreover, there is an absolute lack of elasticity, the waterproofing course being as rigid as the structure to which it is applied. In connection with mastic generally, Mr. Ross makes a statement that sheet mastic is extensively used at present for waterproofing railroad bridges. I think a little investigation will prove that there is no foundation for such a statement. Some railroads do use sheet mastic over a membrane waterproofing as a protection or armor coat to prevent the ballast cutting into the waterproofing. But although I have investigated the systems of waterproofing of practically every railroad east of the Mississippi, I do not know one that follows the practice which Mr. Ross says is extensively used.

I appreciate that I have taken issue with Mr. Ross on a great many points. I might add that there are many other points mentioned which are open to criticism, which I have not mentioned for lack of time.

Lest the points here raised be regarded in a light of destructive criticism rather than that of adding anything to the fund of knowledge which the engineering world possesses on the subject of waterproofing, I would say that the test of time, combined with what is now standard practice on most of the eastern railroads, and many of the western railroads, would indicate that a cotton cloth membrane is the most serviceable and most dependable of any of the membranes now in use, that its cost has not proved in excess of its value, and that its flexibility, strength and elasticity enable it to be used successfully on any type of structure where a membrane waterproofing is applicable.

New York. J. B. W. GARDINER.

Selling Your Own Service

The following useful suggestions on "Job hunting" are given by C. S. Rindsfoos in the December Cornell Civil Engineer:

Always Call in Person When Possible.—I have known men living in New York City, who, after being notified of an opening also in New York, would calmly sit themselves down and write a letter instead of taking the trouble to call in person. Remember—good positions no less than big deals are not put over by letter.

Write a Good Letter.—Often it is necessary to write, especially to open negotiations. In such cases write the best letter that it is in you to compose. Draft it in pencil and work over it. If you do not write a good hand have the letter typed. Make it short and concise. If it is necessary to file your experience do this on a separate sheet. Put "heart interest" into it (as the publicity men say) but don't tell your family history. Imagine you are designing an advertisement in that the composition be so arranged and contain such matter that it:

a. Catches the reader's interest.

b. Holds his attention while reading.

c. Creates a desire to see you or employ you.

Space does not permit elaborating these principles but many good books are available.

Be Prompt.—Remember there are other good men who will be candidates for the same position and the man of energy will not delay.

Study Your Prospect.—If there is an opening for a man to build a dam and you have had experience building both dams and buildings, lay stress on your experience in dam building—that is, the task in which your prospect is interested. If your prospective employer is a Cornell man, let him know that you are also, but don't "rub it in." If you have anything in common, fraternal, social or what not, let it be known, for it identifies you in his mind, but do not depend on that alone to put you over. Try to find out all you can of your prospect's connections before you go to see him. There is usually a way. Try to size up his type when you meet him and stress the points you think will appeal to him. Books which treat of character reading are helpful. Don't try to talk baseball to a thin-lipped, dried-up, theoretical type. Don't talk theory to a red-faced, meat-eating, general superintendent.

Don't Tell Everything You Know.—You may find it necessary to have a second interview. Hold something in reserve. More people lose by saying the wrong thing than by not saying enough.

Have Confidence in Yourself.—If you don't believe you can hold down the job, how do you expect your employer to believe so? What you say is not so important as how you say it. Speak with conviction. Cornell wins more crew races than football games because habit is strong.

Set Your Price High.—You will never get more than you ask for. It is easier to drop your price than to raise it. It is better to wait a month longer and get a higher rate of pay. A month's loss of wages spread out over a year and divided by 12 does not look so large. A man who walks in and says he is a $10,000 man looks bigger than the same man at $5,000. Of course, use some judgment, but if you think you can swing the job ask for all the job can stand. A mouse may look at a king, but a mouse never became one.

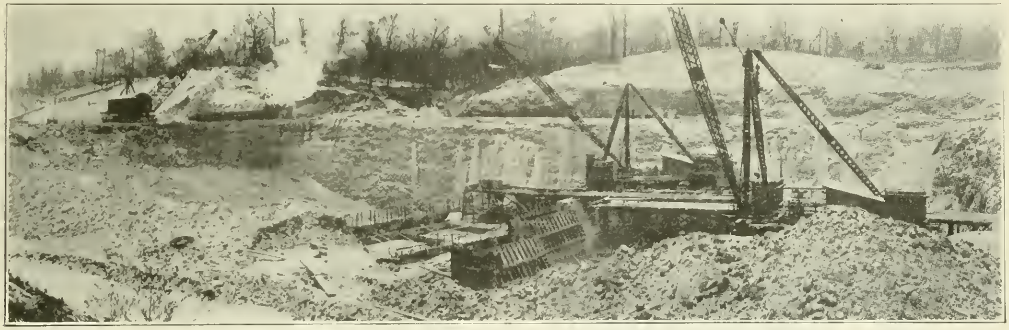
Try to Look Prosperous.—This does not mean flashy clothes with pinched back waist and diagonal pockets. Immaculate linen, shined shoes and a visit to the barber are essential.

Advertise Yourself.—You may be a good salesman, but you must have the opportunity to display your talents. Therefore, never miss an opportunity to widen your circle of acquaintances. If people say you are a self-advertiser, let them say so. It probably means you are getting results. Go to every gathering that is likely to bring you in contact with people of affairs. You cannot tell what one of them may be useful to you some day—and besides you will enjoy it. It is possible to be a "live wire" without being a "fresh guy."

Rock Excavation with Drag Lines for Miami Conservancy Dams

Rock excavation for securing stable foundations for the concrete conduits and outlet structures of the dams of the Miami Conservancy District has been handled by drag-line excavators.

At all the dams except Lockington the rock was of the Cincinnatian formation. This consists of alternating layers of limestone and shale, the limestone occurring usually in layers varying from a fraction of an inch to 5 or 6 in. in thickness. At Taylorsville a few strata were encountered which blasted out in rather massive blocks, 3 to 5 ft. in thickness, but these blocks proved to be made up of several layers of limestone, of more than normal thickness, running up to 13 in., cemented firmly together by ⅛ in. to ¼ in. layers of shale. At Englewood the layers of limestone and shale are distinct, the limestone coming out in hard slabs. At Taylorsville the two kinds of rock are blended or mixed. At Germantown the proportion of limestone to shale is small. The Cincinnatian occurs exposed to the surface, or covered with a blanket, usually of glacial till, varying from a foot or two to 20 ft. thick.



Following Up the Rock Excavation at Taylorsville Dam With Concrete Work.

The great width and depth of the excavation (the maximum cut in the picture being 100 ft.), made it necessary to excavate the upper part first, down to the level of the rock shelf on which the dragline and train stand. (Elevation 789.) Then the lower part was attacked, beginning at the right-hand end in the picture, and working to the left (upstream).

Conditions varied considerably at the different dams, but certain features were common. The cuts were all of considerable length, running up to a maximum of 1,850 ft. and of considerable depth, the maximum at Taylorsville being 100 ft., 77 of which was rock. All had a width for the conduits proper much narrower than for the corresponding entrance and exit channels. And finally, the cuts were all carried a considerable depth below mean low water level, the maximum being 38 ft. and the minimum about 22 ft.

Interesting particulars of the drag-line work are given in the January Miami Conservancy Bulletin, from which the matter in this article is taken.

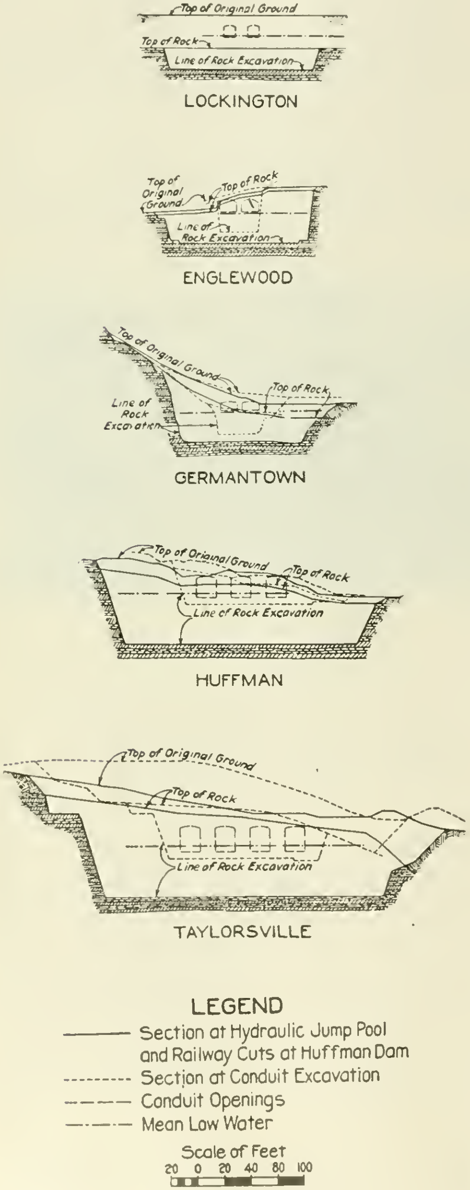
Excavation at Englewood and Germantown Dams.—The general conditions at these two dams were much the same. The excavation in each case was a long, deep trench, 30 to 32 ft. in the bottom width, and widening to over 100 ft. at the ends. The work was done at one trip of the dragline in each case, beginning at the outlet end. The top 7 to 10 ft., including much loose rock, was first removed. Drills were then set up back of the dragline and holes sunk to an average depth on the center line of 18 ft. at Germantown and 28 ft. at Englewood. After blasting with 40 per cent dynamite the loosened material was picked up with the dragline bucket, dumped into 12-yd. air-dump cars and taken by 40-ton locomotives to a spoil bank, where the material was wasted. The total rock thus removed at Germantown was 40,000 cu. yd., the work there beginning about Aug. 1, 1918, and ending in March, 1919. At Englewood the work began May 10, 1918, and ended Nov. 9 of the same year, the total rock removed being 57,712 cu. yd. Not all of the material at Englewood was wasted, a considerable quantity being placed next the down stream toe of the dam to serve as a protection against eddies below the outlet during floods, which might tend to wash away the earth of the dam structure. At Germantown 30,400 lb. of dynamite was used, practically three-fourths of a pound per cubic yard excavated. At Englewood the amount used was ½ lb. per cubic yard. The drills were tripod drills using steam. To trim the sides and bottom and cut out the corners small compressed air "Jap" drills were employed. At Germantown this trimming was kept within reach of the dragline bucket, which was thus able to remove the loosened material. At Englewood the trimmings were thrown by hand into skips or dump boxes which were lifted out of the excavation by a locomotive crane. The final dressing of the side walls and bottom was done with picks, and very carefully, in order to make sure that all loose rock should be removed and a solid surface presented for the concrete of the conduit.

Excavation at the Huffman Dam.—The conditions here were somewhat different from those at Englewood and Germantown. The flood flow provided for at the dam is so great as to require three conduit openings instead of two, necessitating a much greater width of structure. Also the topography and other conditions required that the excavation be carried to a much greater depth. The maximum width at the outlet was 174 ft., and the maximum depth, from the loading track to the bottom of the excavation, was 64 ft. The maximum depth of the rock cut was 60 ft.

The method followed was in general similar to that at Englewood and Germantown. The dragline excavator ran down the approximate center line of the conduits, from which it was able to reach all the material, even to the maximum width of 174 ft. The depth of the cut, however, was such that the machine (a class 24 Electric Bucyrus Dragline with 100-ft. boom and 4½-yd. bucket) could more efficiently take the material out by making two trips. The material was drilled and blasted in three layers, each about 20 ft. thick, this thickness being exceeded in the deepest places in the lower lift in order to reach the bottom. The dragline cleaned away the upper layer on its first trip and all the remaining material on the second. In the deepest place the blasted material was picked up by the dragline bucket at a depth of 64 ft. below the loading track, and 58 ft. below the level of the ground upon which the machine stood. This at the time was a record performance for deep excavation by such a machine in rock material. (It was exceeded a little later by the machine at Taylorsville.) The Huffman dragline excavated a total of 25,000 cu. yd. from one position in the course of this work, which is believed to be also a record dragline performance.

Most of the holes were sunk by a well drill and a wagon drill. The well drill averaged 45 ft. of hole per day at a cost (not including overhead), of $0.27 per foot. The wagon drill did a maximum of 240 ft. in one day. The trimming of sides and bottom, as at Englewood and Germantown, was done with "Jap" drills. All the work of drilling and blasting was kept well out of the way of the excavation, the dragline suffering no delays at any time from this cause. The total amount of dynamite used at Huffman was 70,000 lb. The total amount of rock excavation was 39,500 cu. yd., giving a figure of 0.52 lb. per cubic yard.

Excavation at the Lockington Dam.—The conditions of rock occurrence at Lockington were quite different from those at any other dam. The rock is not of the Cincinnatian formation, but of the Silurian, a later period, comprising rocks of the Springfield, Dayton and Osgood series. The layers are all of hard limestone, from 4 in. to 18 in. thick and practically level, the dip, which is to the north, being imperceptible except to measurement. The material is also much firmer than that of the Cincinnatian formation, permitting its use as plum stones in the concrete or as rip-rap on the slope of the outlet channel below the dam.



Sections of Outlet Excavations.

The [illegible] at all the dams is shown drawn to the same scale. The dotted sections are taken at the conduits proper, the full line sections are taken at the conduit outlets (at the hydraulic jump pool). The openings (in dashed lines) are the conduit openings as they will be when finished. All sections are shown looking downstream. At Lockington practically no excavation (except a small amount for the pool), was necessary.

The outlet location was selected a few hundred feet east of Loramie Creek, where bed rock occurs at a favorable elevation for the foundation. This location was unusually favorable also in that there had been very little weathering of the upper rock layers (the depth being about 20 ft. below the surface), the rock surface being so solid over much of the area that the concrete could be deposited directly upon it. In no case did more than a foot or a foot and a half of loose rock have to be removed to reach solid foundation. The bottom of the hydraulic jump pool was about 16 ft. below the bottom of the conduit proper, requiring an excavation of 4,560 cu. yd. of material. This constituted practically all of the rock at Lockington requiring to be removed.

On account of the unusually favorable winter of 1918-19, the concreting was enabled to follow closely upon the rock excavation at all times, and occasionally to overtake it. For this reason, with the materials at Lockington, heavy blasting was not permissible. It was found most satisfactory to drill shallow holes with "Jap" air drills and load with light charges. This light shooting broke the rock into sizes suitable for concrete "plums" and for the rip-rap referred to. It required more dynamite than would have been required if deeper holes had been sunk, but the excess cost was offset in several ways. The light shooting gave a neat rock line with practically no overbreakage. This in turn enabled the excavation for the two weir foundations, adjacent to the hydraulic jump pool, to be reduced in cross section, the solid unbroken rock base and wall taking the place of concrete. There was no damage to the plant, to the finished work or to the foundation itself done by blasting during the entire work of construction. Forty per cent dynamite was used, with an average of ¾ lb. to the cu. yd. of rock removed.

The blasted rock was not removed by dragline excavator as at the other dams, but by 1¾-yd. bottom dump buckets loaded by hand and lifted by two guy derricks with 105-ft. booms and 120-ft. masts, which were used in connection with the concrete work. Much of the material was dumped directly into the concrete forms in the form of plum stones; the remainder was loaded into 5-yd. dump cars, and hauled away to be built into rip-rap on the east side of the outlet channel, or to be used for other miscellaneous purposes.

Excavation at Taylorsville Dam.—The excavation for the outlet works at the Taylorsville dam is much wider, much longer, and also considerably deeper than any other on the Conservancy work, except in the railway cut at Huffman. The maximum depth is 100 ft., of which 77 ft. is in rock. The maximum width is 380 ft. The length on the center line is 1850 ft., on the east edge 2900 ft. The total excavation is estimated at 773,000 cu. yd., of which 523,000 is earth, and the remaining 250,000 rock. It is evident from these dimensions and quantities alone that the Taylorsville excavation problem must present somewhat different aspects from those at the other dams.

Especially, the disposition of the 523,000 cu. yd. of earth overburden must be considered. This material must be made use of in the dam embankment, and this means that it must be removed ahead of the rock which underlies it, since the rock is not permitted to be used in the dam except as an addition and safeguard. The hydraulic fill method of construction having been settled upon as giving the maximum economy with assured solidity and stability, most of the overburden was washed down by the powerful jet from a hydraulic "giant" or monitor.

A small fraction of the material has been excavated by steam shovel and dragline, loaded into 12-yd. dump cars, and carried across the river by locomotives, where it has been used to build the cross dam extending across the damsite just west of the river, and enclosing the hydraulic fill pool on the east. This took 30,000 cu. yd. The remaining portion, as already indicated, was jetted, sluiced, and pumped by the method of hydraulic fill into the main structure of the dam between the river and the old B. & O. Railway tracks. About 230,000 cu. yd. have been thus disposed of and the process is to be continued. This material for hydraulic fill has been obtained mostly from the river bank north of the north trestle. About the upper 10 ft. of this material as it lies in the bank is composed of glacial till or boulder clay, and is excavated without difficulty. Beneath this, however, and extending down to the Cincinnatian rock, is a layer running to 20 ft. or more in thickness, of extremely tough clay or hard pan, which was as hard on a steam shovel or a dragline as rock would be. It was found best in the end to blast it, and this was true whether it was to be removed by dragline, steam shovel or hydraulic monitor. The holes for this purpose were best drilled from above by well drills, spaced about two-thirds the height of the excavation to be shot, and loaded with black powder at the rate of about a pound per cubic yard, the holes having first been "sprung" or enlarged at the bottom by dynamite.

The earth excavation began in August, 1918, with the work of a Marion 36 steam shovel cutting a shelf for the big dragline to work on. Excavation of the overburden by hydraulic began in September, 1918, and has been continued with various necessary interruptions down to November, 1919, when it stopped until the Baltimore & Ohio tracks could be removed to their new location out of the way of the growing dam embankment. Rock excavation began in February, 1919, and has been steadily continued ever since. The total amount of the latter removed to December 1, was 141,130 cu. yd., leaving about 110,000 cu. yd. still to be done.

The general arrangements for taking out the rock are in the main similar to those at the other dams. The chief tool relied upon for the digging is the dragline excavator, a Lidgerwood machine with 100-ft. boom and 3½-yd. bucket, loading into 12-yd. dump-cars handled by 40-ton locomotives. The dragline works on a rock shelf at elevation 789. The loading tracks are laid on the same shelf and run to the north trestle on a level grade. The south trestle is 10 ft. lower than the north one, and the general elevation of the valley floor on which the dam is built is 770. The rock being deposited as a buttress to the low outer slopes of the dam embankment, this arrangement permits the loaded trains to move on level or downward grades. About 6,000 yd. of rock lying above the working shelf elevation, as well as a considerable yardage of the earth overburden, was removed by steam shovel. The rest is being taken out by the dragline. All the material is carried across the river on the trestles, almost all of the dam embankment being west of the stream, and the outlet works excavation being on the present east bank.

In taking out this rock at Taylorsville a record for deep excavation with a dragline is believed to have been made. The machine stands on a rock shelf at elevation 789. The bottom of the hydraulic jump pool, the lowest point in the excavation, is at 726. The lowest material was thus removed at a depth of 63 ft. below the supporting rock shelf.

The rock was drilled and blasted in two lifts. The upper lift was carried down 26 ft., taking it to the bottom of a heavy seam of the Cincinnatian limestone. Where the holes were carried deeper this thick seam would break out in blocks 3 to 5 ft. thick, which would require to be "blockholed;" that is, drilled and blasted again, to break them into pieces small enough to be handled by the dragline bucket. With the main charge exploded at the base of this seam block-holing was not necessary. The second lift was carried down to the bottom of the excavation, a maximum distance of 37 ft. below the first.

The drills used were three cyclone drills and three air drills of smaller size. The cyclone drills were driven by 7½ hp. alternating current three phase motors, operating at 440 volts and drilling a four-inch hole. Fifty feet of hole per day was considered a good day's work. The holes were spaced 10 ft. each way and up to June were charged with 40 per cent dynamite. Following that, "gelignite" was used, a 72½ per cent gelatin dynamite, which had been sold to Italy for use in the war and on the conclusion of the armistice was advantageously taken off the Italian government's hands by the Conservancy District for its own use. An amount of this explosive ranging from 75 to 100 lb. was used in each hole. The holes were not "sprung;" that is, a small charge of dynamite was not exploded at the bottom of the hole to enlarge it for a bigger charge. Ordinarily this process is an advantage, but in the Cincinnatian it cannot be used, the reason being that the springing charge "funnels out" the top of the hole, the strata being thin and weak, and the broken rock drops down the funnel into the hole, blocking it and making it necessary to redrill.

The large holes were not carried nearer than 2 ft. from the bottom of the excavation nor nearer than 5 to 10 ft. from its sides. These remaining portions were drilled by jap and jack hammer drills and shot with small charges of from 1 to 2 lb. of dynamite. These holes were drilled 3 ft. apart, and next the sidewalls 4 to 6 ft. deep, the holes on this latter case being drilled at the very edge of the excavation. The caps were exploded by electricity tapped from the 440 volt motor line. On one day 235 of these holes were fired at once in this manner by a single stroke of the electric switch.

The quantity of dynamite used per cubic yard of rock blasted has been 0.72 lb. of the 40 per cent explosive and 0.5 lb. for the gelignite.

It would have been desirable if the rock material could have been used in the dam structure, but fears have been entertained for the stability of the Cincinnatian formation, the particular rock encountered, in such a situation. The rock is limestone, for the most part in thin layers and interstratified with much shale, which on exposure to air, frost, and water, sloughs and decomposes in such a way as to create considerable distrust regarding its ability to stand without sliding when placed in the dam embankment. For this reason it is not placed in the dam structure proper, but is deposited as a blanket and buttress adjoining the dam to the north and to the south. Thus used, it becomes a strengthening extension of the very flat outer slopes of the dam embankment.

Railway Construction in 1919

The mileage of new railway lines completed and placed in service in the United States in 1919 was the lowest for any year since the Civil War. According to statistics compiled by the Railway Age only 685.98 miles of new lines were completed and placed in service in the United States in 1919. This total is 36 miles less than the previous low record of 722 miles in 1918. The 1919 mileage Canada was 433.31, which is about three times that of the previous year.

In multiple track construction the 405.32 miles of second track completed in the United States in 1919 is comparable with 681 miles completed in 1919. During 1919, 27.54 miles of third main track and 16.84 miles of fourth or multiple main tracks were completed in the United States as compared with 77 miles and 57 miles, respectively, in the previous year. Canada reported 9.15 miles of second track completed during the year.

The following table from the Railway Age shows the amount of new track built in 1919 in various states:

United States—	Number companies building.	First track.	Second track.	Total.
Alabama	2	11.50	29.70	41.20
Arizona	4	32.40	3.13	35.53
Arkansas	1	2.00	.....	2.00
California	2	69.29	.....	69.29
Colorado	1	.....	20.00	20.00
Delaware	1	.....	8.00	8.00
Florida	1	17.60	.....	17.60
Georgia	2	14.00	12.64	26.64
Idaho	1	4.00	.....	4.00
Illinois	1	6.50	7.81	14.31
Indiana	1	.....	9.00	9.00
Iowa	1	.75	.....	.75
Kansas	2	35.34	48.97	89.95[1]
Kentucky	4	48.94	30.55	79.49
Louisiana	1	.39	.....	.39
Maine	1	.50	.....	.50
Maryland	1	.75	.....	.75
Mississippi	3	62.50	.....	62.50
Nevada	1	2.26	.....	2.26
New Jersey	2	2.62	.....	37.92[2]
North Carolina	1	.....	41.00	41.00
Ohio	1	4.08	.....	7.52[3]
Oklahoma	4	91.60	7.05	98.65
Oregon	3	51.90	.....	51.90
Pennsylvania	2	36.68	6.98	43.66
South Carolina	1	.....	86.35	86.35
Tennessee	2	23.50	23.36	46.86
Texas	3	86.00	10.50	96.50
Utah	1	10.50	15.82	26.32
Virginia	1	42.00	.....	42.00
West Virginia	2	24.00	.....	24.00
Wyoming	1	4.38	44.46	48.84
Totals	54	685.98	405.32	1,135.68
Canada	6	433.31	9.15	442.46

[1] Includes 5.64 miles of third track. [2] Includes 21.9 miles of third track and 13.4 miles of fourth or more track. [3] Includes 3.44 miles of fourth or more track.

Cost Analysis of Replacing Three Crossing Diamonds

This work was done on May 7-9, 1917, by the Michigan Central R. R. It involved the replacing of crossing diamonds at East Main St., Jackson, Mich. One of them was in the westbound main track, another in the eastbound main track, and the third in a sidetrack. The track was crossed by one street railway track of the Michigan Ry. The electric cars averaged 1 per minute during the greater part of the day. Vehicle and pedestrian traffic also was heavy. The weather during the three days was variable, the temperature ranging from 45 to 55°.

The three crossing diamonds were of the Ajax type, 22 ft. 11 in. by 22 ft. 11 in. in size. They consisted of 100-lb. manganese built up. The angle of crossing was 34° 48′. The cost of the three was $2,302.50.

The materials required for the three crossings were as follows:

	Crossing No. 1. W'st-bound main track.	Crossing No. 2. East-bound main track.	Crossing No. 3. side track.
Ties	19	16	15
Rails, 100-lb., 33 ft.	4	4	..
Splices, 100-lb., 23-in. continuous, non-insulated, pairs.	8	8	10
Bolts with nut locks	32	32	40
Tie plates, Sellers	14	9	8
Spikes, kegs	2	2	.6

In addition five 12-ft. ties were divided among the three crossings. Crossings Nos. 1 and 3 each had two pair of special compromise joints furnished by the electric railway. The work was started on May 7 with the following force:

1 yard foreman	$90.00 per month
2 section foremen	77.50 per month
1 assistant foreman	75.00 per month
17 laborers at	2.25 per day
1 team and driver at	6.00 per day

Two roadmasters were on the work part of the day. The laborers included 10 Poles and 3 Americans. Work was started at 7:30 a. m and continued to 5:30 p. m., with 1 hour off for lunch. Except as noted below the 17 laborers worked full time in removing bricks and planking and excavating at crossings Nos. 2 and 3. Two men worked 2 hours removing bolts from 14 joints—2 bolts to the joint—and 1 foreman and 6 laborers worked 1 hour and 15 minutes in hauling ties. Work was carried on during the night of May 7-8 in changing the sidetrack diamond. Four laborers worked from 6:30 to 9:30 p. m., and 23 laborers, 5 foremen and 1 assistant foreman worked from 9 p. m to 6:15 a. m. Three oil and two carbide lights furnished illumination. A work train consisting of engine, crane, 1 flat car and 1 box car, was in service from 10 p. m. to 6 a. m. The charges for this service were:

Train crew and engine crew	$ 1.00 per hour
Engine rental	10.00 per day
Crane rental	20.00 per day
Crane engineer	3.95
Crane machinist	4.44
Box car	.50 per day
Flat car	.50 per day

The time distribution for the work the night of May 7-8 was as follows:

Excavating: 9 to 10:15 = 1 hr. 15 min.—7 men—charged to eastbound main and side track crossings.

Preparing tools: 10:15 to 11:45 = 1 hour 30 min.—5 men—charged to side track crossing.

Cutting bolts, pulling spikes—11:45 to 12:03 = 18 min.—8 joints—12 men—side track diamond.

Removing diamond: 12:04 to 12:13 = 9 min.—7 men; hauled 150 ft. This includes time of bringing crane 100 ft., adjusting chains and lifting diamond clear of track—does not include time of haul or of depositing.

Removing ties: 12:06 to 12:25 = 19 min.—19 ties carried by hand 35 ft. by 7 men.

Leveling ground: Placing ties—2-in. cut—12:25 to 1:32 = 1 hr. 7 min.—14 men levelling—7 men carrying and placing ties.

Placing diamond: 1:33 to 1:40 = 7 min.—7 men. This includes time of placing diamond in approximate alignment with the crane, unfastening chains and moving crane clear of work.

Aligning diamond: 1:33 to 1:40 = 7 min.—20 men; 2:52 to 3:02 = 10 min.—16 men.

Attempt was first made to force diamond into position by ramming with a rail, but it required the sawing of two rails to make the diamond fit.

Sawing rails: 2:30 to 2:50 = 20 min.—2 rails.

The 2 rails were sawed simultaneously by 2 men at each rail. Michigan Ry. men did the work on the street railway rails of the diamond.

Bolting, spiking, placing tie plates, tamping ties: 3:02 to 6 a. m.

Flagging: 11:45 to 6 a. m.—2 men.

Time tests as follows were made:

Cutting 2 nuts and removing 2 bolts from 1 joint:

42:20 to 43:50 = 1 min. 30 sec.

55:25 to 56:40 = 1 min. 15 sec.

Two men worked with chisel and sledge.

Removing 10-in. plank—16 ft. long (av.): Average of 6 men worked: 12:31, 12:34 — 3 min., 12:37 — 3 min., 12:39 — 2 min., 12:56 — 17 min. (4 planks).

Pulling spikes—1 man—2:08 to 2:16:30 = 8 min. 30 sec.: 15 sec.; 30 sec.; 2 min.; 30 sec.: 25 sec.; 25 sec.; 50 sec.; 10 spikes—2 men worked on same spike.

Rail sawing (Mich. Ry. Co. men and tools). Test No. 1: 2:30:15 to 2:48:00 = 17 min. 45 sec. 2 men worked—3 blades broken; time to change 1 blade—1 man: 1 min. 45 sec.; 1 min. 20 sec.; 1 min. 15 sec.

Test No. 2: 2:31:00 to 2:50:30 = 19 min. 30 sec. 2 men worked—4 blades broken; time to change 1 blade, 1 min. 00 sec.; 1 min. 05 sec.; 1 min. 15 sec.

The day force on May 8 consisted of 5 foremen, 1 assistant foreman and 23 laborers, who worked from 7:30 a. m. to 3 p. m. with pay for 1 day, and 2 foremen, and 12 laborers, working from 2 to 5:30 p. m. In addition there was one team and driver employed from 10 a. m. to 5:30 p. m. with pay for 1 day.

The equipment consisted of track tools and push car.

The work done during the day consisted in surfacing sidetrack crossing, 3 men working all day, and excavation to bottom of ties, 14 in.

Work during the night of May 8-9 was carried on at the eastbound main track crossing and westbound main track crossing.

The force consisted of 7 foremen, 1 assistant foreman and 35 laborers, who worked from 10:45 p. m. to 5:45 a. m., and were credited with pay for 1 day.

The equipment consisted of 3 oil (4 burners) and 2 carbide lights. A work train was in service from 10:00 p. m. to 6:00 a. m. The charges for this were the same as previously noted.

The time distribution for work on eastbound main track was as follows:

Removing planking, digging out dirt along rails, removing rail blocks, etc.: 10:45 to 11:47 = 1 hr. 2 min.—22 men; 11:17 to ——, average of 12 men worked 2 hours; length removed, 8x2x40—640 ft.

Flagging—2 men all night.

Cutting bolts, pulling spikes. Eastbound main: 11:47 to 12:03 = 16 min.—10 men cut 8 joints with chisels.

Removing diamond: Eastbound main: 12:03 to 12:20 = 17 min.—diamond hauled 150 ft.; 9 men adjusting chain and steadying the diamond. This includes time of adjusting chain and lifting diamond clear of track. Note: 9 min. spent in dropping diamond and readjusting chain.

Removing ties: 12:10 to 12:21 = 11 min.—17 ties carried 35 ft. by hand by 12 men.

Leveling ground, 2 in. removed: 12:22 to 12:37 = 15 min. 13 men worked; 12:37 to 12:55 = 18 min.—8 men worked.

Loading new diamond: 12:20 to 12:48 = 28 min. This is time taken by crane to pick up diamond and carry it 750 ft. 9 men helping; crane idle rest of time.

Placing ties: 12:37 to 1:05 = 28 min. Av. of 5 men carried 16 ties about 60 ft.—3 men spaced the ties with picks.

Placing diamond: 1:06 to 1:14—10 men helping. This included bringing up crane about 100 ft., dropping diamond into approximate alignment, removing chain and moving crane away.

Aligning diamond: 1:14 to 1:33—24 men moved diamond into exact position by prying with bars.

Bolting, spiking, putting in tie plates: 1:33 to 2:27 = 56 min.—Average of 14 men. Tamping ties: 30 min.—3 men.

Removing 4 lengths of rail: Removing planking, digging out dirt along rails, removing rail blocks and removing rails were done at same time on different portions of the work. They were also carried on simultaneously with operations on diamond. Labor varied and time periods overlapped, so that no exact data was obtained.

Laying 4 lengths of rail, replacing temporary planks: Time of laying—1:54 to 2:25. A gang worked at each end of diamond, each gang laying 2 rails. Number of men averaged 9 and 12 for these gangs. Rest of time was spent in relaying planking. Cutting of rails necessitated boring. One joint in each rail received only 2 bolts, the boring not being done at the time.

The time distribution on the night of May 8-9 for work on the westbound main line crossing was as follows:

Cutting bolts, pulling spikes: 2:27 to 3:03, 36 min.—6 joints; 8 men worked with chisels.

Moving diamond: 3:03 to 3:06:30 = 3 min. 30 sec. Diamond was pushed 15 ft. to one side by sliding over rails—28 men.

Removing ties: 3:05 to 3:11 = 6 min.: 19 ties were carried by hand 35 ft.—15 men.

Grading to depth of 2 in.: 3:07 to 3:25 = 18 min.—16 men; 3:25 to 3:33 = 8 min.—4 men.

Placing ties: 3:25 to 3:43 = 18 min.—19 ties were carried 75 ft.—6 men carried and 4 men spaced.

Placing diamond: 3:57 to 4:03 = 6 min. Diamond was brought in by crane, placed in approximate alignment, chain removed and crane backed away—10 men helping.

Aligning diamond: 4:03 to 4:13 = 10 min.; 24 men pried it into place with bars.

Bolting: 4:13 to 4:31 = 18 min.; about 10 men worked.

Removing old diamond: 9 min. Crane ran in on westbound main, picked up old diamond and backed away.

Spiking, placing tie plates: 4:45 to 5:45—average of 8 men.

Surfacing: 4:15 to 5:45 average of 4 men.

Removing rails. Time overlapped that of other operations, labor varied, so no accurate data obtained.

Laying rails (4 lengths): 4:20 to 5:45 = 1 hr. 25 min.

Replacing planking: Time to lay rails 4:20 to 4:55 = 35 min. Remainder of time was spent in replacing planks. A gang worked at each end of diamond, each laying 2 rails. Average of 10 and 12 men in these gangs. More men worked on planking. Each rail was cut. The boring was not done at the time. One joint of each rail therefore received only 2 bolts.

The force employed on May 9 consisted of three foremen and six laborers, working from 8 a. m. to 11:30 a. m.; two laborers, working from 9 a. m. to 11:30 a. m., and 3 foremen and 12 laborers, working from 12:30 to 5:30 p. m.

The time distribution was:

Surfacing: West bound main—2 men, 8:00 to 11:30 a. m.; 7 men, 12:30 to 5:30 p. m.

East bound main 5 men, 8:00 to 11:30 a. m.; 2 men, 12:30 to 5:30 p. m.

Side track—2 men, 12:30 to 5:30 p. m.

Part of time was spent gathering ballast along tracks within 150 feet of crossings. Three foremen were overseeing the work practically the whole day.

Tightening bolts: One man worked all day—3 crossings.

Putting in splice: Two men of Mich. Ry. worked 2½ hours, placing 2 pairs of compromise joints (furnished by Mich. Ry.). This included 2 trips to shop to mill splice.

The cost of installing the three crossing diamonds may be summarized as follows:

WEST-BOUND MAIN TRACK CROSSING.

	Total.
Labor:	
Day of May 8—	
1 yard foreman, ¾ day at $90	$ 2.60
1 assistant yard foreman, ¾ day at $75	2.16
4 section foremen, ¾ day at $77.50	8.94
2 section foremen, ⅜ day at $77.50	2.24
20 laborers, ¾ day at $2.25	33.75
12 laborers, ⅜ day at $2.25	10.13
Night of May 8—	
35 laborers, ½ day at $2.25	39.38
Day of May 9—	
1 yard foreman, ⅓ day at $90	1.15
2 section foremen, ⅓ day at $77.50	1.99
9 laborers, ½ day at $2 25	10.13
1 laborer, ⅓ day at $2.25	.75
1 team and driver, ¾ day at $6	4.50
Total labor*	$117.72
Equipment and Service:	
Engine rental, ½ day at $10	$ 5.00
Crane rental, ½ day at $20	10.00
Flat car, ½ day at 50 ct	.25
Box car, ½ day at 50 ct	.25
Train and engine crews, 4 hours at $4	16.00
Crane crew	4.60
Total equipment and service	$ 36.10
Grand total†	153.82

EAST-BOUND MAIN TRACK CROSSING.

Labor:	
Day May 7—	
1 yard foreman, ½ day at $90	$ 1.73
2 section foremen, ½ day at $77.50	2.98
1 assistant yard foreman, ½ day at $75	1.44
17 laborers, ½ day at $2.25	19.13
1 team and driver, ½ day at $6	3.00
Day May 8—	
1 yard foreman, ¼ day at $90	.87
1 assistant yard foreman, ¼ day at $75	.72
4 section foremen, ¼ day at $77.50	2.98
2 section foremen, ⅛ day at $77.50	.75
20 laborers, ¼ day at $2.25	11.25
12 laborers, ⅛ day at $2.25	3.38
Night May 8—	
35 laborers, ½ day at $2.25	39.38
Day May 9—	
1 yard foreman, ⅓ day at $90	$ 1.15
2 section foremen, ⅓ day at $77.50	1.99
7 laborers, ½ day at $2.25	7.88
1 laborer, ⅓ day at $2.25	.75
1 team and driver, ¼ day at $6	1.50
Total labor*	$100.88
Equipment and rental same as West-bound Main Track Crossing	36.10
Grand total†	$136.98

SIDETRACK CROSSING.

Labor:	
Day May 7—	
1 yard foreman, ½ day at $90	$1.73
2 section foremen, ½ day at $77.50	2.98
1 assistant yard foreman, ½ day at $75	1.44
17 laborers, ½ day at $2.25	19.13
Team and driver, ½ day at $6	3.00
Night May 7—	
23 laborers, 1 day at $2.25	51.75
Day May 8—	
3 laborers, 1 day at $2.25	6.75
1 yard foreman, ⅓ day at $90	1.15
Day May 9—	
2 section foremen, ⅓ day at $77.50	1.99
2 laborers, ½ day at $2.25	2.25
1 laborer, ⅓ day at $2.25	.75
Total labor*	$ 92.92
Equipment and Service:	
Engine rental, 1 day at $10	$ 10.00
Crane rental, 1 day at $20	20.00
Flat car rental, 1 day	.50
Box car rental, 1 day	.50
Train and engine crews, 8 hours at $4	32.00
Crane crew	8.39
Total equipment and service	$ 71.39
Grand total†	164.31

We are indebted to Mr. A. M. Van Auken, assistant engineer, Monon Route, for the information from which this article was prepared.

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*7 foremen worked night of May 8 without additional pay.

†This total does not include complete cost of surfacing.

Another Estimate of Needed Railway Expansion

A writer in the Railway Age has made an analysis of the requirements of fixed property on the railroads in the United States in the next three years in order to make up for the present deficiency and provide for the current annual improvements.

While it is admitted that the demand for second and third main tracks is not directly proportional to the increase in traffic, as shown by the statistics of past years, it is, on the other hand, evident that the unusually rapid increase in traffic during the last few years makes necessary the construction of a greater mileage of multiple tracks than was required in the previous 10-year period used for comparison. Accordingly, the estimate is that about 15,000 miles of multiple main tracks and 40,000 miles of additional side tracks and yard tracks will be needed, which at the present costs of $40,000 and $18,000 respectively per mile, make a total of over $1,250,000,000.

The amount which should be expended to promote economical operation during the next three years, including grade reductions and line changes, is estimated at $600,000,000. Based on what has been expended under the Railroad Administration and considering the present deficiency, $250,000,000 is considered necessary for engine houses and shops.

Station buildings, including several large projects in St. Paul, Chicago, and New Orleans, together with the many smaller buildings scattered all over the country, which are sorely needed, bring this estimate to $300,000,000 for the 3-year period. The grand total is thus about $2,500,000,000.

"Normal" Value in Appraisals*

By CECIL F. ELMES,

Engineering Staff of Sanderson & Porter.

If there is something "normal" in prices and values, which commissions and appraisal engineers have discovered, and if it really is a discovery and not an error, then by all means let us examine it and have the benefit of it. If there is a "normal" price, for commodities, let us go back and discover it for any particular article. Let us find how much of the time the article is obtainable at this rate, what the deviations are, how serious they are. I have endeavored to do this and have been at pains to go back quite a distance into history.

First of all, I have taken perhaps the most basic commodity known to man, wheat. I went back to the records of what wheat sold for on an average, not for the last 10 years, or 50, or even 100. I went back more than 600 years, to the year 1260, and took the average annual price at which wheat was actually purchased in England in every one of those years. If I had covered only a century or so, someone might assert that a more extended period and more complete statistics would overthrow my conclusions. Chart 1 shows, expressed in dollars per bushel, what wheat cost on the average in England every year from 1260 down to and including 1918.

I will ask you to examine this chart and tell me, any of you, if you can, what is the normal price of wheat. The word "normal," as applied to such a chart, would mean that you could draw a horizontal line across the chart somewhere which would represent a fair average price of wheat to take all the time, year in, year out. The market might sometimes be a bit above it, sometimes below, but the general tendency would always be to work back to that line. Now, look at the chart. There is no horizontal line of this character, none which would have the slightest value as a guide. Here is the first commodity and we find at once that there is no fixed figure which can be used as an average market price for a bushel of wheat. There is no such thing as a "normal" price of wheat.

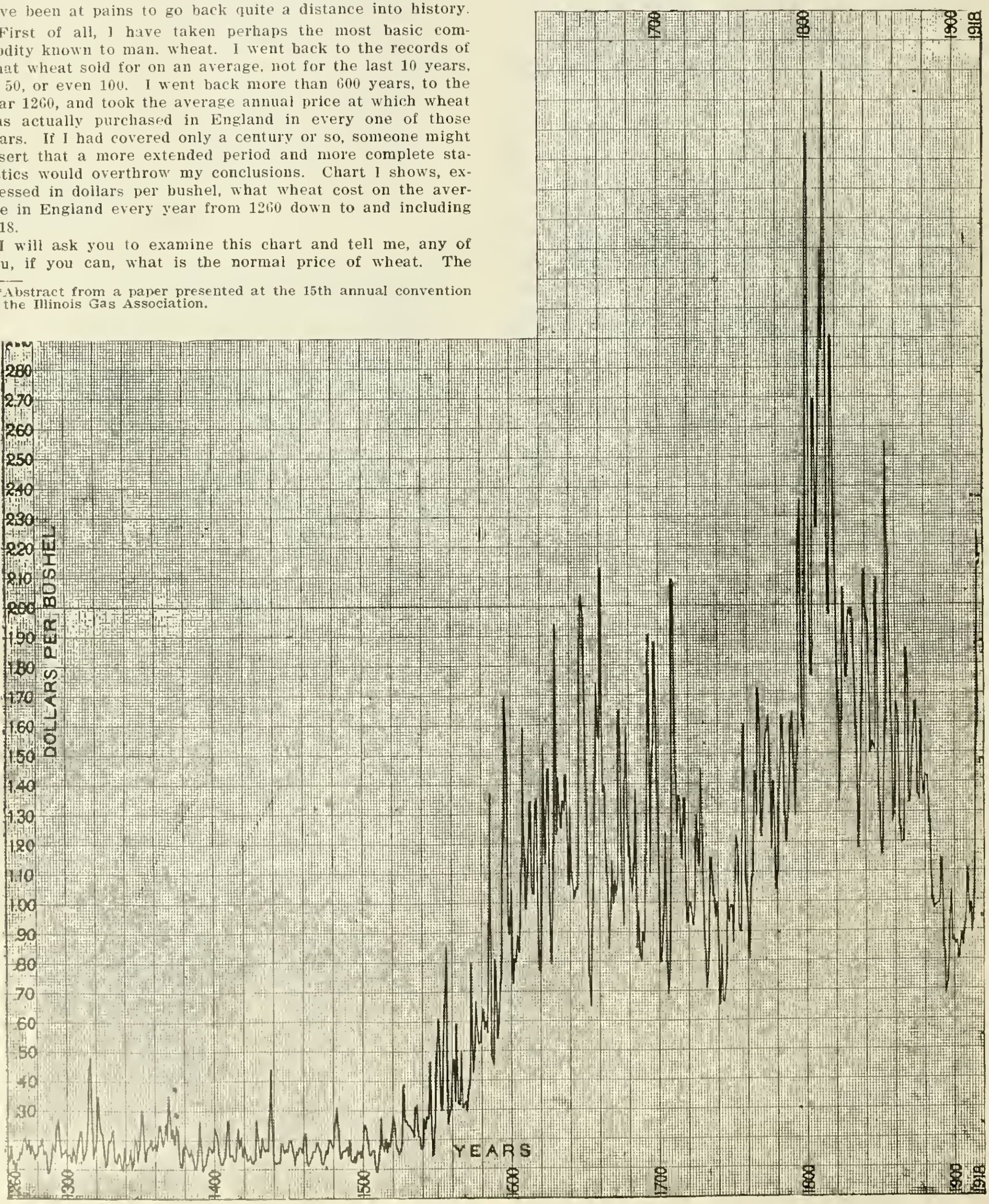

Chart I—Average Cost of a Bushel of Wheat in England From the Year 1260 to the Year 1918, Inclusive.

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*Abstract from a paper presented at the 15th annual convention of the Illinois Gas Association.

Next let us assume that a commission or one of these engineers says, "Well, perhaps there is not a 'normal' value in the sense of some fixed price per bushel holding good through the ages. We didn't really mean that. We meant only that there was a normal rate of increase." Of course, the actual use of the word "normal" in such rate cases as I have cited cannot be so construed. It means a fixed market price in dollars for commodities and it means nothing else. But let us overlook that for a moment. Look at the chart once more. If there were a regular, or "normal," rate of increase, then instead of a horizontal line we could draw one at an angle to the horizontal. But who, looking at the chart, will venture to draw such a straight line and believe in it? Of course, you can draw one if you choose; that is just the trouble. You can draw a hundred—and one is as good as the next.

For the purposes of this paper I have analyzed five basic articles:

Wheat Iron Lead
Cattle Sheep

It will be easy to criticize my choice, but you must bear in mind the limitations inherent in such a work. Records of many important commodities are wanting, records of others are so confused, for one reason or another, as to be difficult to employ. On the whole, while it is easy to object to these items, they are the most representative I could get and it is fair to claim that all of them are of prime importance in our daily life and are in a true sense of the word "basic" commodities. I will also remind you that the reason for using English figures instead of American is because of the great range of time covered—six and a half centuries.

In Chart II is shown the average price of a ton of wrought iron in England from the year 1277. If we can challenge any serious minded person to deduce the "normal" price of wheat from Chart I, we can equally question his ability to name the "normal" price of wrought iron.

In regard to this chart, I will repeat the statement made in regard to wheat—that no intelligent student of the subject will specify any one figure as a "normal" price. No such student will draw a straight line at an angle to the horizontal (corresponding to a "normal" rate of continuous increase or decrease in price). It can be done easily enough, but in scores of different ways on each chart. Each such line is a guess and worth just as little as the next guess. No busi-

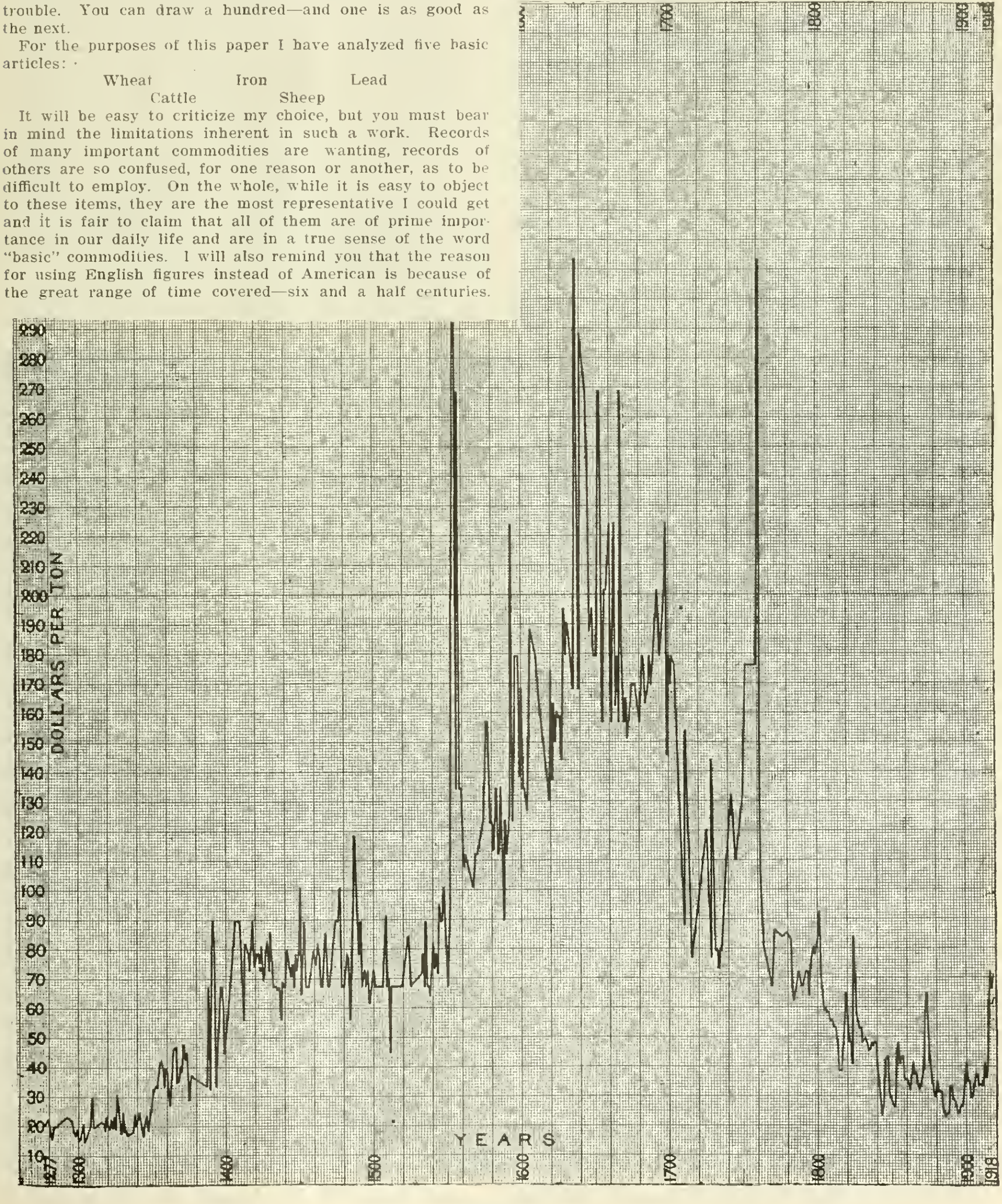


Chart II—Average Cost of a Ton of Wrought Iron in England From the Year 1277 to the Year 1918, Inclusive.

ness man would dream of employing one of them in market operations.

Relation Between Commodity Prices and Wages.—There is one angle to this subject which the serious student might bring forward. He might say that while the price of a commodity varied apparently according to no law, yet this is merely the fluctuating value of the dollar, and there is really no corresponding fluctuation in the "accessibility" of the commodity itself. He might say that we can get rid of all this apparent irregularity and wildness if we would consider only how much of the commodity the "normal" man might come by daily as a normal thing. It took as much bread and meat, let us say, to sustain a man in 1300 as in 1900. Express the product of this man's daily toil in dollars, convert these dollars into bread or meat—and see whether there is a "normal" yield for such a man's toil.

In Chart III are shown the average daily earnings, expressed in dollars, of two types of artisan in the history of England, the carpenter and the mason, from 1260 down to 1918. I took them because they were the most dependable and the most easily obtained. Statistics on common labor were available, but common labor back in the 13th, 14th and 15th centuries was in many respects hardly more than slave labor. Some of the old records that I noted seem to indicate little less than the actual bodily purchase of the man or woman.

Now, we will take the daily wage of these artisans and the average price of the most essential of our commodities—wheat—and see how much wheat this "normal" man's earnings could produce for himself and his wife and children. Of course, he could not actually put all his money into wheat. This represents his entire earnings, out of which clothing and a home and all other necessaries had to be provided But, expressing it all in bushels of wheat, which I have done in Chart IV, we have a yard-stick with which to measure the "accessibility" of the necessaries of life to the "normal" man.

I will confess that the historical significance of this chart far outweighs the use to which I am putting it here. Alongside of its vital import as a record of human prosperity and human suffering the whole subject of public utilities becomes a secondary matter. For you will at once perceive that this chart is a bird's-eye view not merely of commodity prices but of Anglo-Saxon civilization for 650 years past.

Note, in the middle ages and the early middle ages, for 300 years, wild fluctuations. The man's earning power changes from nearly a bushel to almost a quarter of a bushel per day and back again within the space of 10 years. The reason is that so runs the story of an insular, isolated people. Commerce was in its infancy, transportation was of a rudimentary kind, imports and exports were unknown. The community stood or fell according to the season and the harvest. If the harvest was bounteous men lived in plenty, if the harvest was lean they starved.

Here, again, in the beginning of the 16th century note the long, progressive decline running through a century and a half. It traverses a supposedly golden age of English history, the time of Queen Elizabeth, of England's rise to maritime power, of the Spanish Armada and Sir Walter Raleigh, of Spenser, Milton and Shakespeare. Yet this chart tells a different and a bitter story, but nevertheless a true one. It shows a progressive decline in well-being of the working classes from the dissolution of the monasteries to the time of Cromwell. And the decline ends where you might expect —in civil war.

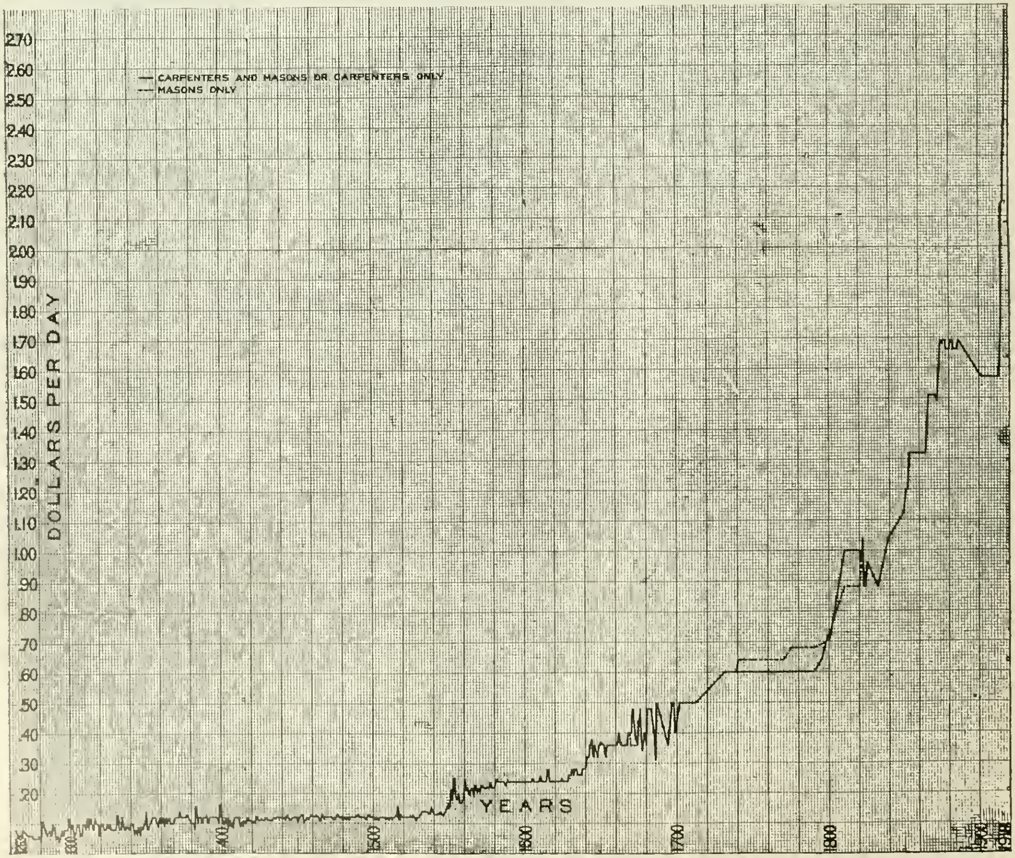


Chart III—Average Daily Wages of Carpenters and Masons in England From the Year 1263 to the Year 1918, Inclusive.

There is a rare opportunity here for the student of history from the early middle ages down to the great and continuous improvement which set in since the middle of the 19th century. An interesting essay could be written about the two outstanding depressions or low spots in the chart, showing how the industrial and economic misery which each of them represents was accompanied by anarchy and civil strife, local or world-wide. But I will not digress further. I will content myself with pointing out how this chart fails utterly to provide any indication of a "normal" accessibility of commodities. It is its very failure to be "normal" that makes it a most sensitive index of the deep historical and economic changes in status and welfare of labor.

Having thus passed the subject in review, I will restate my contention in positive terms.

1. There is nothing "normal" about commodity prices whether:

(a) Expressed in terms of the cost of an individual commodity,

(b) Expressed as a relation between different commodities, or,

(c) Expressed in terms of an average man's ability to purchase them.

2. There is no such thing as a "normal" value.

"Normal" Value—Customary Method of Application.—Now, if we can object to the conception of "normal" value, we can object still more to the method by which it is applied. We would be well satisfied if appraisals in which it is employed could always be directly and readily challenged. But this is not the case. Quite generally, instead of being out in the open where we can grapple with it, this erroneous conception is buried by the engineer under a mass of figures. The engineer prices his inventory– applying his unit prices to each item, so much for a pump, so much for a hammer. These unit prices are carried out, or extended, the extension added and the total is what is called the "bare-bones" or net appraisal of the company's physical property. This "bare-bones" figure, and the items going to make it up, are under a column captioned "Reproduction Cost New." Mark that word "New."[3] The engineer then usually proceeds to make a deduction from these figures for depreciation, and arrives at a new set of figures, which he calls "Present Value." Mark that word "Present." Slightly different titles are often employed, but the variations are unimportant.

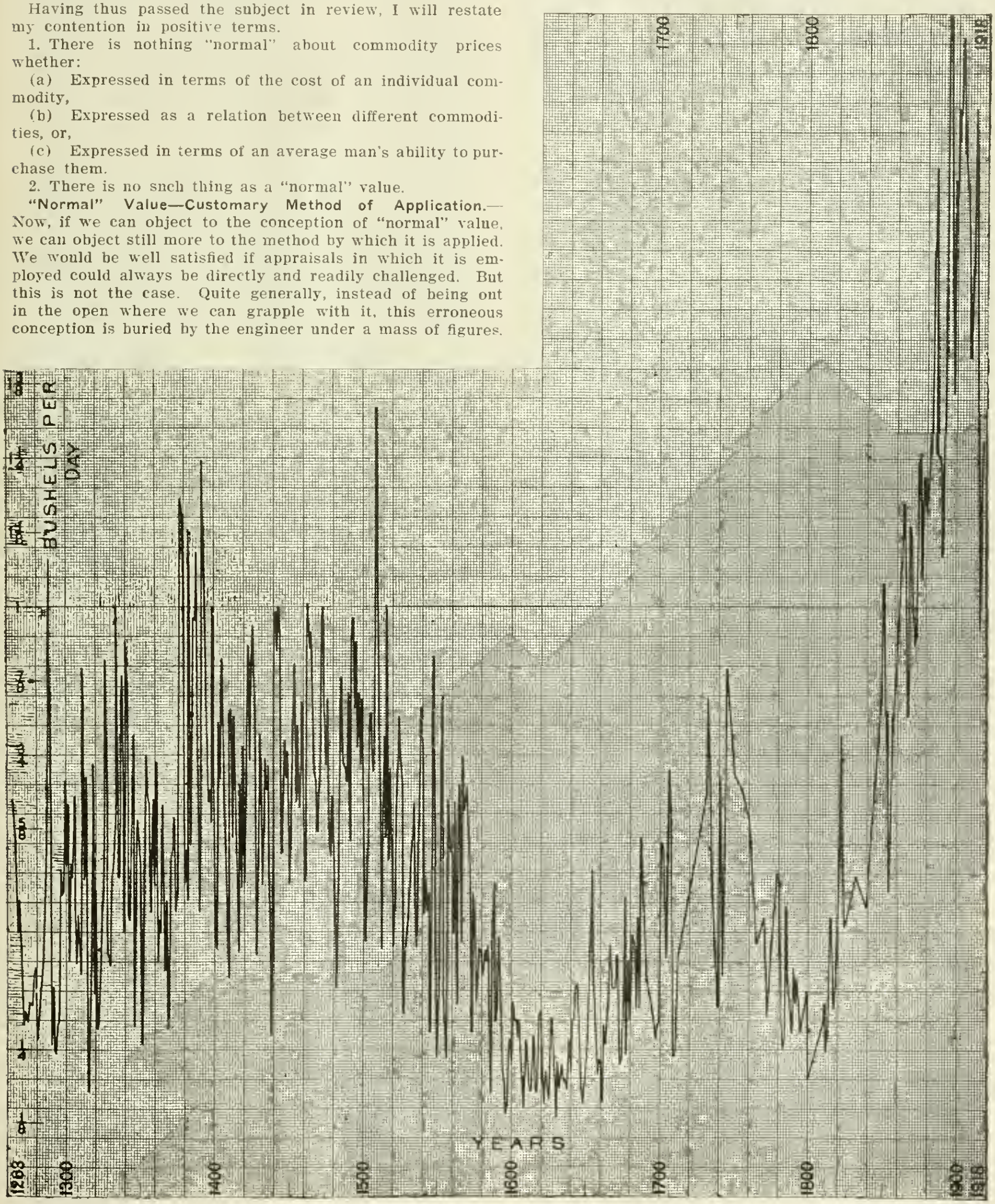


Chart IV—Average Purchasing Power of Carpenters' and Masons' Wages in England Expressed in Bushels of Wheat.

Webster's Unabridged Dictionary defines the word "present" thus:

"Present—Now existing, or being at this time; not past or future."

When an engineer uses plain words out of the dictionary we are entitled to give them the meaning the dictionary gives them, and the engineer is not entitled to alter that meaning, and yet this is precisely what he does.

He knows that in a certain town and on a certain day he will have to pay 50 ct. for a hammer. He comes to the item of hammers in the inventory. Does he put down 50 ct.? No, he does not. He falls back upon a theory—any one will do. He takes the theory that the prices of five years ago are about right, and so values hammers at 25 ct. apiece. Or the theory that the price of hammers is to be determined today by averaging what they used to cost from 1910 to 1915, and puts down, say, 30 ct. Or he even falls back upon our old friend, the "trend curve" and builds a theory upon a theory. He says, "I know the market price today is 50 ct. in fact, but looking at the way the market price was rising between 1910 and 1915, hammers ought to have risen only to 35 ct."

This engineer is informed as to the current market prices. He is paying them out of his own pocket day by day. Yet, because he is dealing with a public utility, he sets them aside, does not even record them, and "theorizes" an entirely different set of prices. Then he turns in the result to a commission as an appraisal, under such misleading captions as "Reproduction Cost New" and "Present Value," and this body in its turn, dubs the collection a "normal" value and uses it as representing the present worth or value of the property. There have been rate cases all over the country where the regulating authority has determined the value of a public utility "today" without a particle of evidence submitted by either side by which the market value "today" of the separate items of the company's property could possibly be ascertained.

Please understand that I am not attacking the personal rectitude of the engineer at all. He acts in this matter in entire good faith. I do not in the least doubt his honesty, but sometimes I wish he had a keener sense of humor. We all admit that a commission is entitled, in its discretion, to decline to accept any particular price, or to modify it if it sees fit. If it is unfair to the utilities, they can endeavor to obtain redress by setting their arguments forth to a court of review. But at least, let facts be clearly set off and let the engineer cease to obscure and befog matters by injecting assumptions and theories and suppressing or disregarding actual facts and present costs.

A "Home" Application of the Plumb Plan.

The gentleman who guides the destinies of the column is desirous of moving his lares and penates to Philadelphia and is looking for a suburban home which will afford comfortable shelter for two persons and a dog.

We desire, neither to buy nor rent the property of which we are in quest. It is our plan to have the government take over the house, issue to the owner in payment therefor government bonds bearing interest at the rate of 4½ per cent per annum. Immediately after the transaction is concluded we agree to move in and take possession of the property. If at the end of a year of occupancy and after allowing ourself full salary, paying all household bills and other expenses incurred, there remains from the income received during that time a surplus, we agree to split that surplus fifty-fifty with the government and the people of Philadelphia. If there is no surplus there will be nothing to split, but it is a part of this covenant and agreement that we are to remain in indisputed possession of the house.

"A preposterous proposition" you say. So it is. But it is no more preposterous, nor does it differ greatly from the proposition just made by the brotherhoods in connection with the railways. The brotherhoods claim to have 2,000,000 persons behind their proposition. Contingent upon the government acceeding to our request, we agree to enlist 5,000,000 supporters of our house-renting plan.—Philadelphia Public Ledger.

Improvements to Mexican Railways.—The Mexican government is reported planning the expenditure of $75,000,000 this year for new rolling stock and repairs to the National Railways of Mexico.

Every Engineer a Counter Propagandist

Editorial in Chemical and Metallurgical Engineering.

The philosophic Goethe lived in days when Germany was poor in pocket, but great in mind. And when, in "Faust," he desired to represent in Mephistopheles the spirit of evil, he made him the spirit that denied all things. He took the ecclesiastical devil and made him a devil of everyday life; for the spirit of evil of our day and generation is that which denies. Let us consider the subject for a minute or so.

The real trouble with labor just now is that in following Karl Marx it has come to the conclusion that labor is the true and sole source of all wealth, and that the representatives of capital are, in effect, the receivers of stolen goods; that they have got control of the machinery of laws and justice, and that the only way for labor to come into its own is to strike, and strike, until the administrators of capital are driven to cover, leaving capital behind them. Then labor will take this and enjoy its fruits. It may not sound reasonable, but such is the gospel.

Now if, in working for a man, a laborer believes his employer to be, in effect, a receiver of stolen goods, and therefore in criminal possession of his property, he cannot have faith in such a man, nor will he want to see him prosper. As a worker he will do as little as possible. If he belongs to the I. W. W., or is a Communist, or a Socialist of the radical wing, these are likely to be the views he holds. And the propaganda of these organizations, which he gets and the rest of us do not, teaches that government and courts are based upon an organization of capital; that they are founded on false premises, and should therefore be overthrown. The plan is to supplant the government by a "proletariat dictatorship" until a government of and by workers is established.

This is the doctrine that foments strikes, and resents profit-sharing, or any kind of internal organization of workers. The control of workers, it is held, should be from the outside, so as to destroy the minions of capital who are in control of industry.

Among many agitators this doctrine has become an "idée fixe," and they can no more be argued out of it than a gamecock can be reasoned into leading a life of amity with his Plymouth Rock brethren in a barnyard. They don't want to be argued out of it, and they have a string of verbiage in reply to argument that would confuse a Philadelphia lawyer. Their business is rebellion; rebellion is their normal state, and if there were to be brought about the general strike which they are always trying to initiate, or the rebellion of the proletariat which they constantly urge should ensue, they would be quick to arise in opposition to it. They have no sense of system or of order, and whoever establishes system or order becomes their enemy thereby. This they constantly prove, even while denying it. Their policy is destructive, but never constructive. They hold the Russian Soviets to be a glorious success, and declare that those of us who do not agree with them have been misled by the false reports of a capitalistic press.

Not all our workingmen are built that way. Many are ambitious, and want to gain property for themselves; they want to own property, in time, and to be protected in their ownership. But we are neglecting our opportunity if we do not reason with them, and strive to keep their minds open while the apostles of anarchy are seeking with every persuasion at their command to close them. We must go out and do this thing ourselves, and we must put heart into this self-imposed task because men in revolt will not listen to paid pacifiers. We cannot trick them into assent, either, because trickery, like murder, will out. Then it breeds dissent. To accomplish this is difficult, and often disheartening, but it is the only way out. Industry requires eager and enthusiastic labor rather than cheap hands, and unless those of us engaged in industry become teachers of good citizenship by example as well as by precept, our industries are doomed. Neither invention nor astuteness can meet the deadening influence of denial and hate which thousands of agitators are preaching in nearly every industrial center, and which, if they succeed, will bring about such a reign of terror and confusion as to kill freedom—freedom for the individual man and woman. Not only will it put an end to legitimate personal opportunity, but it will utterly destroy free government.

Maintenance of Way Methods of the Connecticut Co.

The Connecticut Co. operates some 680 miles of street railway in the state of Connecticut. Of this track 45 per cent is unpaved, 17 per cent is paved with macadam, 8 per cent with a better grade of paving than macadam, and 30 per cent has so-called permanent pavement on a concrete base. In a paper presented at a recent meeting of the New England Street Railway Club, Mr. W. R. Dunham, Engineer Maintenance of Way of the Connecticut Co., gave some interesting particulars regarding the methods employed by his company in maintaining this track. The matter following is abstracted from his paper.

Maintenance of Way Organization.—The organization consists of the maintenance-of-way engineer who reports to the vice-president and general manager, three assistant engineers, six assistants to take care of surveys, drafting, etc., and a clerk. Each assitant engineer has a definite territory of about 221 miles of track. It is his duty to make estimates and generally supervise all work, to insure that standards are followed and to act as the eyes of the department. He makes frequent inspections of his division, and in company with the roadmaster visits all the work on his division. There are 11 operating divisions on the property under the jurisdiction of the local managers or superintendents, but the divisions of the assistant engineers combine two or more operating divisions. There are four roadmasters on the property with headquarters at the larger centers, and one general foreman acting as roadmaster. This gives an average of 142 miles of track per roadmaster and 95 miles for the general foreman. Like the assistant engineers the roadmasters' divisions are not necessarily the same as the operating divisions, but in some cases include two or more.

In addition to the roadmasters, there is a general foreman of welding, who reports directly to the engineer of maintenance of way. This foreman of welding has charge of all the welding work and trains the operators. He keeps the machines in repair and has general supervision of this work.

A foreman in the city section averages about 20 miles of track during the six months from October to March inclusive, one man for each mile of track from April to June inclusive, and one man for each 2½ miles of track from July to September inclusive.

Track Construction.—With a typical section of track construction, for the Hartford division, due to the character of the soil we first lay a concrete trough, the bottom of which slopes from the sides to the center. A ballast of broken stone is laid on this and at low points it is drained by tile pipe into city manholes. At the sides the concrete is built up so as to make side walls. We thus have a concrete trough filled with broken stone. On this ballast we lay our standard ties and rails. A 6-in. concrete foundation is then laid on top of the ties and ballast for the pavement. The soil is a brick clay on the Hartford division and during the winter and spring months this works up through telford or broken stone ballast laid without concrete. The above described method was developed to meet these conditions and has worked very well.

We use ties 6 in. x 8 in. 8 ft. long, spaced 24 in. center to center and beginning 12 in. from the rail ends. On single tracks the ends of the cross ties are lined true on the right-hand side going either north or east. Where one end of the tie only is exposed as in side locations on highways, the exposed ends are lined true, while with double tracks the outside ends of ties are lined true. We are not using creosoted ties on our lines.

In permanent pavement we have practically standardized on steel ties as furnished by the International Steel Tie Co. These ties are spaced 6 ft. on centers, the joint ties being placed directly under the joints. The bearing surface of these ties under the rails is 3 ft., so that there is a space of about 3 ft. between bearings. As the bottom two-thirds of the rail is imbedded in concrete, this helps to support the rail, and results so far have been very satisfactory with no perceptible rail movement.

The use of steel ties cuts down the amount of grading, both in width and depth, so that the higher first cost of steel ties over wood ties is decreased by the smaller number used and the lower cost of excavation. By welding the face of the rails to the ties, the cost of cross-bonds, labor and material can be eliminated, thus further reducing the cost. The labor cost of laying this type of track is less also as the ballast can be spread to a level surface at the tie base grade and the ties can be laid directly upon it, obviating any appreciable lift for surfacing except for final adjustment. There are also one-third fewer rail fastenings per foot of track for steel ties and practically no gaging.

Our standard T-rails are 5-in. 80-lb. A.S.C.E. section for all work except where it is contemplated that a permanent pavement may be installed, for which this rail will not be adapted. For permanent pavement we use 7-in. 95-lb. or 6-in. 100-lb. T-rails, A.R.A. Type A, except in one city where by original grant a grooved girder rail must be used. In this city 9-in. 125-lb. Boston grooved girder rail is the standard. We specify Bessemer process steel for T-rails and A.E.R.A. standard open-hearth high-grade carbon for grooved girder rails.

Reclamation of Old Rails.—As our lines are made up of a combination of those of former individual companies, we have, in our tracks 57 different rail sections not including guard sections in special work. Since 1914 we have gone into the reclamation of old rails rather extensively, and during the past five years 4,776 tons of old rails have been reclaimed by electric welding and grinding; 6,520 tons of new rails have been used in this renewal. This represents a net saving in cash of $200,000 based on pre-war prices for new rails and scrap. Practically all of this rail has seen from 15 to 20 years of service. From present appearances, the rails are good for as long a service as they have already given. The average annual cost for montenance of this track has been from 1.7 ct. to 3.2 ct. per foot. This maintenance consists of building up with the electric welder and then grinding.

Our standard joints for both high and low T-rails are the continuous joints, 24 in. long, drilled "5-4-5" for four bolts. We use 1-in. bolts for high T-sections and ⅞-in. bolts for low T-sections. All bolts have "O.K." nuts which consist of a patented nut and nut lock combined. For grooved girder rails we use 12-hole channel bars with 1-in. bolts and "O.K." nuts.

Rail Welding.—From 1908 to 1911, inclusive, we welded 15,000 joints in various sections of rails by the Lorain process. These were mostly high T and girder rails, and this welding has been a success. Some of the welded sections have had to be removed, due to municipal paving work, but the percentage of actual joint failures has been low. Most of the rail welded had been in service 15 years or more under city traffic before the welding was done. During the past year we have welded 1930 joints and have had no absolute breaks. There have been instances of fracture in one of the four seams, but these have been infrequent, and were due more to inexperience of the operators and ourselves with the process.

On practically all our new work and on extensive retieing, we tilt our rails toward the track center, 1 to 20. We believe this reduces our pavement breakage along the rails, as the resultant of the load passes through the rail parallel with its vertical axis and nearly coincident with it. This removes the tendency of the rail to overturn and relieves the adjacent pavement from the lateral crushing effect. The load is also applied on the center of the railhead on new rail and has the same effect as on the proposed curved railhead. On old rail which has become beveled to the taper of the car wheel, tilting transfers the wear from the gage line to the outer edge of the head, gradually moving toward the center. When the center is reached, the whole rail head tends to wear equally.

The type of tie plate which we use for tilting is made under the Lundie patent. We originated this to accommodate the large number of rail sections with varying widths of base, as this enables us to carry but one standard plate in stock. Our standard plate will fit many of our rail sections and there is no necessity for right and left plates.

Remedying Bent Joints.—A great many joints, especially in suburban tracks, become surface bent. These bends may not extend more than a few inches back from the rail end, but if not taken care of properly, they will develop a serious track condition. These bends are caused by the use of joint plates of too light a section, loose bolts, or general lack of attention. Our first step in remedying this condition is to install an Abbott plate under the joint. The joint ties are then well tamped, so that the surface bend may be rolled out by traffic. The Abbott plate is a piece of flat steel bulldozed in the center for stiffness. For angle bar joints the ends are turned up to form a buttress for the angles to rest against.

In tracks where the surface bends are quite long we raise the whole joint with a vertical rail bender after installing the Abbott plate and tightening the bolts. The joint ties are tamped hard, but the shoulder ties are left a trifle slack. In addition to this, we have in some instances welded the angle bars to the rail and to the Abbott plate.

Many joint failures are due to loose bolts, and many loose bolts are caused by the stretching of the bolt beyond its elastic limit when the joint is first made. In order to determine the ease with which bolts may be stretched when installed, we made some tests in 1913 on ¾-in., ⅞-in. and 1-in. bolts. We found that in some instances a stretch as high as 80,000 lb. per square inch on the bolts was being placed with a 38-in. wrench. With a ¾-in. bolt we found that at 63,000 lb. per square inch, the bolt had stretched 7/32 in.

Office Records of Special Work.—A proper record of special work is one of the important considerations in special work maintenance. In order to identify the pieces in the field with the blue prints in the office, we have a diagram of each operating division and the diagrams for each of the divisions are bound in book form and are brought up to date the first of every year. This shows every special track-work layout on the system and each layout has its own number. All plans of layouts drawn in the office and every manufacturer's plan has a circle in the top right-hand corner with the name of the division in the upper half, and the location number in the lower half of this circle. These plans are kept in envelopes with the divisions, street names and location numbers on them, and are filed in drawers in a cabinet, one or more drawers to a division.

There are about 1,350 special work layouts on the system, or an average of two per mile of track. Special track work is ordered to our own specifications, which are made after a careful study and conferences with the different manufacturers. We have three types in use, manganese or hardened steel centers, manganese or hardened steel inserts and built-up construction. The selection of the type for any particular location is based upon the traffic conditions. In the fall of each year the roadmasters and assistant engineers inspect the various locations and make reports as to requirements. The reports are checked up by personal inspection of some of the locations by the engineer of maintenance of way, and the material is ordered for the locations which in his judgment are in the worst condition. Orders for the materials necessary for repairs of other locations are held in abeyance until the season opens, and are placed during the season.

Our standard steam-road crossings are manganese spines continued through the steam lines. The main guard and easer rails consist of one double web casting, to which trolley rails are bolted with heavy steel angle bars bent to the angle of the crossing. The trolley line has guard rails through the crossing with rolled steel separator blocks.

In addition to the renewal of pieces, we use the electric welders for building up special-work centers, abutting rail ends, etc. Welding manganese centers is not very successful, however, and about 50 per cent of the welds last only for a short time. The work done on these centers is more in the nature of a temporary patch to last until a new piece can be installed. When welding center plates which have become loose, we find it more satisfactory to take the loose plates out, weld them and then replace them, as the heat generated in welding tends to loosen the plate if it is tightened up first and then welded.

Labor-Saving Devices for Track Work.—We have gone into labor-saving devices to quite an extent and have found their use a great benefit. For example, in breaking out 9-in. 106-lb. girder rail, electrically welded, two 15-ton Barrett jacks are employed. Six men and a foreman performed this work. The track was paved with macadam and this gang broke out about 500 ft. of single track per day, with no excavation except for jack holes. After the rails are removed, they are taken from the job by a crane car, which has a maximum capacity of 1½ tons at the end of the boom when extended at right angles with the track. The reach is 27 ft. and the maximum lifting capacity is 3 tons. We have four crane cars of this type.

A Keystone digger is used for excavating. With this machine we have excavated at a cost as low as 7 ct. per cubic yard. This was an extreme condition, perhaps, but in general the machine cut our cost of excavation about 67 per cent. When not in use on our own work this machine is rented out and the money received for rental, so far, is nearly equal to the original cost of the machine. In figuring the cost above, interest on the investment, depreciation and annual repairs are included. Other laboring-saving machines used are a small "Rex" mixer and a "Thew" electric shovel. On one job where we used the Thew shovel we were, on account of a breakdown, obliged to do some excavation by hand and so had a very good basis for comparison. We found that with the shovel our excavations cost 71 per cent less than by hand. We also found that due to short hauls our service in hauling away material cost 22 per cent less with the shovel, as we could load so much faster.

We have 12 pneumatic tie tampers on our lines, which reduce the cost of tamping about 25 per cent over hand tamping and also give us a better-tamped track. All of the electrical equipment on these machines is standard for our cars. This was arranged so that they would be interchangeable with our standard car stock.

In addition to using the tampers for tamping ties, we use them for breaking out concrete by the use of jack-hammers and drills. A drill will bore a 1¼-in. hole through 6 in. of concrete in from 45 seconds to one minute. We drill a set of holes and sledge or jack the concrete into small sections. Tie tampers are also used for cleaning cement grout from salvaged paving block. Two men with one machine clean from 250 to 350 blocks an hour, which is much quicker than the work can be done by hand.

Track Paving and Bridges.—The Connecticut statutes provide that the railways must keep in repair so much of the highways as lie between the rails and 2 ft. on each side of the outer rail. This has always been interpreted to mean entire renewal of pavement when the municipalities renew the street surface. For the past two years we have been laying concrete where we could and have over 200,000 sq. yd. of this particular kind. We have also laid about 260,000 sq. yd. of wood block. We have 309 bridges on our system, or an average of a bridge for every 2.2 miles. In order to maintain a proper record of these, we number all bridges. The first two figures used indicate the division and the remaining figures are the bridge number, thus beginning at the west end of the system. "Bridge No. 101" indicates the first bridge on the Stamford division, and "Bridge No. 421" indicates the 21st bridge on the New Haven division. The record kept in the office shows diagrammatically the location of all bridges and by the color the limiting loads. The record also lists the bridges by numbers with the locations and local names. This is brought up to date the first of each year and a copy is furnished the general manager for his information. In addition to this diagram a loose-leaf system gives detailed information as to span or spans, the limiting loads, and what part of the structure is the limiting feature.

Cost of Freight Train and Locomotive Service

The following figures of the Operating Statistics Section of the Interstate Commerce Commission recently quoted in the Railway Age are of interest as showing the present trend of costs in a certain phase of railway operation:

	July, 1919.	June, 1919.	May, 1919.	April, 1919.	Mar., 1919.	Feb., 1919.
Cost of train service per 1,000 gross ton miles	100.6	101.8	103.9	112.7	119.5	126.5
Locomotive repairs and engine-house expenses	32.7	33.7	35.4	38.6	40.8	43.1
Locomotive fuel	28.1	29.3	30.6	34.3	37.5	40.3
Other locomotive supplies	2.5	2.6	2.6	2.9	3.1	3.4
Enginemen and trainmen	31.9	31.5	31.1	32.4	33.5	34.8
Train supplies and expenses	5.4	4.7	4.2	4.4	4.6	4.8

Convention of Material Handling Machinery Manufacturers.—The Material Handling Machinery Manufacturers' Association will hold an open convention at the Waldorf Astoria Hotel, New York, N. Y., Jan. 29-30. This meeting is intended to be a "get together" two days for all manufacturers of mechanical handling machinery, accessories and equipment. Manufacturers will be welcome from any part of the country who make cranes of any kind, hoists, winches, portable, gravity, and power conveyors, industrial trucks, tractors and trailers, bulk handling machinery, elevators, motors and electrical control apparatus, batteries, ball-bearings, wire and manilla rope used in the construction of mechanical handling machinery, hand lift trucks, etc., etc. Zenos W. Carter, 35 W. 39th St., New York City, is secretary and manager of the association.

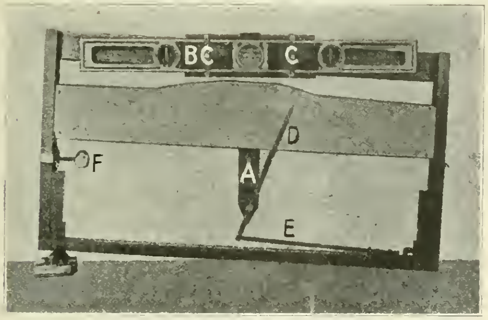
A Home-Made Grade Indicator

Mr. Charles R. Harte, Construction Engineer, The Connecticut Co., New Haven, Conn., writing in the Electric Railway Journal, describes an effective home-made grade indicator which was developed and used on the lines of his company.

In collecting the data regarding electric lines which the American Electric Railway Association furnished the War College, The Connecticut Co. found it necessary hastily to determine grades on a considerable mileage of tracks which had been built by predecessor companies, for which plans and profiles were incomplete or in many cases entirely lacking.

The base sheets for the work had been enlarged from the United States Topographic Survey sheets, which are on a scale from 1/62,500 to 1/20,000. It was necessary to locate the beginning and the end of each grade of 3 per cent or over, and to determine its magnitude.

J. B. Whittemore, engineer Shore Line Electric Ry., solved the problem for his track my hanging a carpenter's level in a car window so it could swing in the plane of the glass, marking on the latter a circle 2 ft. in diameter having for its center the pivot on which the level turned, and dividing the circumference, for about 2 in. above and below a horizontal line into hundredths of a foot. By keeping the bubble of the level central, the rate of the grade on which the car was standing or operating could be once read on the scale, 1 per cent being represented by a division approximately ⅛ in. long.



Grade Indicator Developed by the Connecticut Co. for Use in Emergency Work.

With care the grade could be determined with Mr. Whittemore's device within ½ of 1 per cent. The Connecticut Co., however, felt that more rapid and more accurate results would be had by the use of a larger scale, and that as the work was to extend over several divisions it was desirable to have the "gradienter" so it could readily be fixed in any car.

The illustration shows the device as developed. To one end of the steel bar A, 2 in. wide, ⅛ in. thick and 10 in. long, were fastened two wood arms between which the carpenter's level B just fitted and was held in place by the straps CC, while a screw on the center line and midway between the blocks served as a pivot. The brass needle D was pivoted to the lower end of A and to the swinging arm E, the result of the leverages being that a movement of 0.01 ft. at the end of the level which was just 2 ft. long moved the end of the needle about 1 in., the exact relation varying somewhat in different parts of the scale since the point of the needle does not follow a true circle.

An adjusting screw and nuts from an old skate served to connect the swinging arm to the frame and to allow adjustment, and the scale was graduated by first setting the level parallel to the base, by careful measuring at each end and adjusting the needle to the center of the scale at the same time. The needle was then moved until the end of the level had traveled 0.01 ft., then 0.02, and so up to 0.15, the position of the needle point being marked each time. These points were then checked by moving back by the same steps, while the ½ of 1 per cent points were measured directly on the scale, halfway between the points secured by trial.

In service the frame is held in a car window by the clamp F, which wedges it into the frame, and the needle is brought to the center mark with the level bubble central when the car is on track which is known to be level. This adjustment is necessary, particularly with older cars, since due to unequal spring strengths the window sills are not always parallel to the track. One man then keeps the bubble central, by moving the needle, while the observer notes the readings desired—in our case 3 per cent or over—and the points at which the changes occur.

The results made with the device were checked on the return trip, and in the very few instances of disagreement a second test was made. For the war maps, where 1 in. on the sheet represented 1,667 actual feet, the grade-ends could probably be located as accurately as they could be plotted, under regular run conditions. However, having in mind the assistance (?) which would be given the men by curious passengers the users of the device deemed it wiser to run a "special." This gave opportunity to locate the grade points more accurately, and to tie them definitely to known reference points such as bridges, roads, curves or the like. When, as often happened, the grade point was some distance away, the special could, with due regard to the regular schedule, of course, be held long enough to tape or pace the required interval.

The device proved very satisfactory for the purpose intended. Clamped and adjusted in an automobile or wagon it would serve equally well to determine highway or street grades; with a longer and more sensitive bubble tube the grade could be read to smaller percentage fractions, but of course in such cases particular care would have to be taken to prevent any play in the lever connections. In the arrangement shown machine screws were used in holes just large enough to allow free motion without backlash. These would doubtless soon wear loose if used to any great extent, and for a permanent or more accurate form a spring to hold the pivot against the other parts should be added. However, the simpler form will serve for many purposes, and with the thought that it may help others it is here described.

Electric Railway Construction in 1919

During 1919 the urban and interurban electric railways of the United States and Canada built 140.57 miles of track extensions. This mileage is practically one-half of that recorded for the previous year. The amount of track rebuilt, however, exceeds that of 1918 by 234.45 miles. This, according to the Electric Railway Journal, undoubtedly indicates the trend of track work for the next few years. The following table reprinted from the above mentioned paper gives a comparison of track construction for the years 1907-1919:

	Extensions					
Year.	No. of cos.	Urban track.	Inter-urban track.	Electrified steam lines.	Total.	Track rebuilt.
1907...	*	*	*	......	1,880.00	*
1908.	157	1,174.5		84 00	1,258.50	*
1909..	160	774.7		112.40	887.16	*
1910.	217	1,204.8		192.40	1,397.20	*
1911.	223	1,105.0		86.50	1,191.50	*
1912..	171	869.4		80.80	950.20	*
1913...	181	974.9		119.00	1,093.90	*
1914..	163	716.5		229.00	946.40	*
1915.	136	596.0		448.20	1,044.2	*
1916..	104	115.40	240.9	388.00	744.3	*
1917..	121	251.10	125.60	66.60	442.7	375.40
1918..	80	216.41	97.41	275.70	589.53	155.43
1919.	73	110 90	29.67	287.60	428.17	390.64

*Not available.

It will be noted from this table that 287.6 miles of electrified steam lines were opened up in 1919. Of this amount 280 miles were for the Chicago, Milwaukee & St. Paul R. R. and 7.6 miles for a new classification yard at Cedar Hill, Conn., for the New York, New Haven & Hartford R. R.

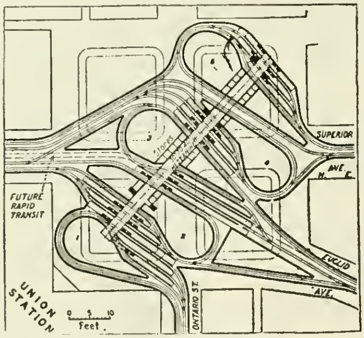
Annual Meeting of The Associated General Contractors.—Owing to the impossibility of making suitable arrangements for the annual meeting of the Associated General Contractors of America at Chicago on Jan. 20-21, the dates for this convention have been advanced to Feb. 18 and 19. According to the tentative program the convention will include two national conferences on construction, to be held at 2 p. m., Feb. 18 and Feb. 19, which will be open to members, general contractors and the public.

Subsurface Loop Terminals Versus Rapid Transit

In a discussion of a recently made report on rapid transit for Cleveland, Mr. John P. Fox, consultant on traffic problems, has brought out some valuable points in a contribution to The American City, from which the following is taken:

A report like the one recently issued on rapid transit for Cleveland ought to attract more than local interest for several reasons. In the first place, such a report is of great value to other cities in suggesting how similar investigations ought to be made. The cities of the country are giving too little attention to the vital need of rapid transit lines as factors in directing growth in the right direction. Cleveland, Pittsburgh, St. Louis, Baltimore are all certainly large enough for rapid transit, the too long postponement of which means a loss of time to the citizens, a lack of healthful circulation of the inhabitants, and the menace of congestion in business districts if not in tenements.

Briefly speaking, in order to relieve the traffic congestion in the downtown section, it is proposed by the engineers to place the surface cars underground in shallow subways, all terminating under the Public Square in a large terminal having five loops and fourteen platforms. Ten subway tracks will enter and leave this terminal, spreading out into seventeen tracks in the station itself. It is recommended that the subways for surface cars eventually become part of a rapid transit system radiating from the Public Square, the first line built to be located on Euclid and Detroit avenues, crossing the city from east to west, this first route to be supplemented by successive branch lines.



Suggested Track Arrangement for Loop Subways Under Public Square, Cleveland.

The cost of the initial surface car subways and the terminal under the Public Square is estimated at about $15,000,000 at present prices. As this expenditure would hardly bring in any additional revenue, though making some saving in the expense of operating the present surface cars, it is recommended that the necessary funds should be provided by the issuance of municipal bonds.

Admirable as many of the features of the report are, it is hard to look at the plan of the enormous subway terminal for the Public Square without feeling that the Cleveland scheme is fundamentally wrong in placing the surface cars underground at such great expense. Huge as the proposed terminal is, it is not as large as it rightly ought to be, or as complicated as it probably would have to be in the near future in order to handle the traffic adequately. For one thing, the plan does not provide separate loading and unloading platforms for the cars as they come in, a feature found absolutely necessary at the largest terminals in Boston, after long experience with conflicting currents of passengers. Neither does the single mezzanine passage feeding the seventeen tracks appear likely to be adequate for incoming, outgoing and transfer passengers. Park Street Station, the principal terminal of the first Boston subway, proved inadequate almost as soon as it was opened, twenty-two years ago, and the station has had to be altered and enlarged greatly at different times since.

Of course, if the $15,000,000 subway loops proposed for Cleveland are to be carried entirely by general taxation, the financial objection to the plan does not have so much weight. At the same time, is it worth while to spend such a large sum for a temporary expedient which has proved so unsatisfactory in Boston from every standpoint?

There are objections to the Cleveland plan even more fundamental than those already raised. Most serious of all is the influence which the terminal would have in crystallizing congestion of business and traffic about the Public Square. Even with surface cars removed, automobiles would quickly take their place, and there might be no real relief as far as the pedestrian is concerned. But to go still further, would not Cleveland, and every other city with a congested business district, do well to try to spread such congestion out as much as possible, instead of building a terminal which would tend to more concentration than ever?

If the experience of New York with subways has shown any one thing, it is the advantage of spreading business out by means of a rapid transit line. Today the business district of New York is no longer limited to the lower end of Manhattan Island. It really extends at least from 59th St. to Flatbush Ave., Brooklyn, a distance of about 6 miles. Assisted by the limitations on the heights of buildings imposed in 1916, office buildings, stores, theaters and hotels are spreading out all along the subway lines, all tending to reduce the congestion on the streets and on transportation lines, the dangerous concentration of population, and many other evils of an overcrowded business district. The development of 42nd St. as an office section has had surprising advantages. Suburban passengers from New York, New Jersey, Connecticut and Long Island can now come in on their trains to the Grand Central and Pennsylvania Stations or by the Hudson Tubes and walk comfortably to their work; or they can live on Murray Hill and the section to the north and walk to their offices equally well. The workers are so greatly benefited by the spreading out of business along the subway lines, and with all the congestion on the rapid transit lines there is probably more walking to work in New York than ever before in its history. Employes of the wholesale stores on 4th Ave. and the retail stores on 5th Ave. throng the cross-town streets every night and morning, coming from their homes on the east and west sides.

New York City used to be cited as a monstrosity of bad planning, with all the business at one end of narrow Manhattan Island requiring all workers to be transported in one direction. The round city has long been held up as the ideal type, with all the business located at the center, and the population carried back and forth daily by radial transit lines. The New York Subway has greatly changed ideas upon this subject. The ideal type of city today would appear to be the long one where business is spread out along a rapid transit line, so that people can live on each side of the business district and walk to their work, instead of having to ride into the congested center of a round city, where skyscraper buildings are darkening the streets and offices more and more, and where land values are soaring beyond all reason.

So while Boston contributes the negative lesson to city transit and development, by showing the wastefulness and undesirability of costly subway terminals for surface cars, New York contributes the positive lesson that real rapid transit should be used to spread out congestion and to extend cities in the right direction along carefully determined lines. And this spreading out cannot be undertaken too soon. Instead of postponing rapid transit as long as possible, cities should undertake it at the earliest practical opportunity. All over the world, the larger cities are in need of the powerful influence of rapid transit lines to decentralize business and direct future growth. It is a mistaken idea that industry alone needs decentralization. Business needs it just as much, and as the railroads should be used to spread out factories, so rapid transit should be employed by municipalities to spread out business and relieve congestion.

New Chilean Railroad.—The Chilean congress has authorized the government to contract with a Chilean-Ecuadorian syndicate for the construction of a railroad to extend eastward from Porto Bolivar, Ecuador, into Brazil and thus give a specific outlet to a rich territory hitherto inaccessible. It is proposed to extend the line about 563 miles to Porto Para on the Amazon river in Brazil at a cost of about £6,000,000 sterling.

The Technical Engineer and the Pending Railway Legislation

Where do the technical engineers and other unorganized railway employes come in in the wage adjustment provisions in the railway legislation now before Congress? The Esch Bill, passed by the House of Representatives on Nov. 17 provides for the creation of three boards of adjustment, each authorized to hear and decide all controversies between the railroads and certain classes of their employes with regard to wages, hours of service and conditions of employment, and three commissions on labor disputes to make final decisions on all matters referred to them by the three boards of adjustment. These boards of adjustment, however, provide for representation only for existing organized employes. The Cummins bill, passed by the Senate on Dec. 20, provides for a committee on wages and working conditions, composed of 8 members—4 representing labor and 4 the railway carriers—to have jurisdiction over controversies respecting wages and working conditions of employes. Only organized labor appears to be recognized in this committee. The Esch bill also contains a provision for the creation of other boards of adjustment, if desired or needed, but it would be extremely difficult, in fact practically impossible, for unorganized employes to obtain any representation on such boards.

The railway employe who does not belong to a union is seemingly left out in the cold by both bills, as regards future wage adjustment. This point has been brought to the attention of Senator Lenroot and Congressmen Esch and Britten by Mr. A. M. Van Auken, formerly chairman of the political action committee of the American Association of Engineers. In the letter to Congressman Britten, Mr. Van Auken suggests that there be incorporated in the bill a provision creating in the Interstate Commerce Commission an information bureau which would gather all available data regarding all classes of employes, and would compile data showing for each class:

Education required of a beginner in work.

Period of apprenticeship required.

Pay during apprenticeship.

Regularity of employment; amount of time commonly lost through bad weather or other causes.

Possibilities of advancement.

Whenever a wage hearing is held it would be the duty of this bureau to supply the Commission with all the facts at its disposal. It also would be the duty of every commission hearing wage questions to report the present pay of all technical employes and subordinate officers who make designs for, supervise work of, or inspect work of the men whose pay is being adjusted. Mr. Van Auken's letter brings out some interesting points regarding conditions in railway service. We quote from it as follows:

> Dean Cooley of the University of Michigan stated recently in a letter to the Engineering News-Record that, had those graduates who entered railroad service gone into other branches of engineering, they would now be receiving double their present salaries. The effect of this statement will tend to turn students to other fields.
>
> Engineers are essential to railroads. Safety to travelers calls for block signals, equipment in good condition, adequate bridges and good track. All these are the work of the engineer, and upon his ability their quality rests.
>
> How were the engineers treated under private control of railroads? In his speech in the House of Representatives on Nov. 17 last, Hon. Thetus W. Sims gave official figures showing the remuneration of many classes of railroad employes for each year from 1892 to 1914 when classification was changed. I quote the following:

	Av. per day, 1892.	Av. per day, 1900.	Av. per day, 1914.	Per cent inc., 1892 to 1914.
Railroad general officers....	$7.62	$10.45	$16.06	111
Railroad minor officers......	5.75	5.22	6.48	13
Organized labor (train service)	2.68	2.76	4.01	50
Semi-organized (station agents, operators, dispatchers)	1.81	1.77	2.29	27
Semi-organized (shopmen)..	2.23	2.02	2.75	24
Unorganized (track labor)...	1.49	1.45	1.90	28
Unorganized (office clerks)..	2.20	2.19	2.54	15

> A perusal of these figures will show how very badly two classes have fared—minor officers and office clerks. And these two under the Adams classification include the engineers, civil, structural, signal, mechanical and electrical.
>
> It is not to the interest of either the owners of the railroads, the higher officers, the fellow employes, or the general public that the standard of ability or training of the designing class shall fall. We want the best designing and most efficient execution if we secure safety of travel and economy of maintenance.
>
> On the Pennsylvania Lines in 1917 assistant engineers who had finished college and were experienced were designing and executing work and receiving less pay than first-class carpenters working under their orders. On the Burlington R. R. at the same time trained engineers who were designing improvements and repairs to engines and cars, were paid only 75 per cent what was paid piece-work inspectors in shops. The engineer must be educated and know, besides his college-taught knowledge, the U. S. safety laws, the rulings on safety of the Interstate Commerce Commission, the recommendations of the American Society of Mechanical Engineers, and the recommendations of the Master Mechanics' Association. He could qualify as piece-work inspector in one week. It would take the inspector five years to qualify for the engineer's work.

A New "Tie Nipper"

A new tool used in connection with the spiking of ties has been developed at Davenport, Ia., on the property of the Tri-City Railway Co. It is described as follows in the Electric Railway Journal:

The usual process is not only uncomfortable for the man on the end of the bar, but requires the use of a man and bar on each side of the tie. The new device requires only one man for this purpose and the leverage is such that no jar is felt by the operator. It consists of a lever with a side projection or head to fit over the ball of the rail and act as a fulcrum while a foot at the short end of the lever goes under the tie. The particular function of this device is to clamp rail and tie together firmly while the spiking operation is being performed.

Spiking Tie Held in Place by New "Tie Nipper."

The "nipper" as it is called, consists of four parts, a lever, handle, head and foot. These are put together with pins and cotter-pins for purposes of interchangeability and adjustment to various types and sizes of rail. The foot is a casting and is made in various lengths for any height of rail. For a 7-in. rail the distance from the pivot in the bar to the top side of the horizontal foot is 10 in. The lever or bar to which the foot is attached is ¼ in. x 2 in. and a 1¼-in. pipe which fits onto the end gives a total length of 6 ft. The head which fits over the rail is also a casting and is made in a sufficient number of types to fit any rail. This head is set 4 in. from the end of the bar.

In operation the foot is first placed under the tie, the head is then placed over the ball of the rail and by means of the handle lever the tie is held firmly against the rail base while being spiked. An actual test made over a given length of track resulted in the accomplishment of the work with the "nipper" in one-third the time necessary when the old method was used. At the time of the test the trackmen did not know a comparison was being made and were not familiar with the new device.

The fact that the handle is quickly detachable makes the tool convenient for the tool box. The total weight is about 26 lb. as equipped for use with a 7-in. T-rail. The device has been patented by its designers, Messrs. Emmons and Johnson of the Davenport track department.

SCIENCE OF MANAGEMENT

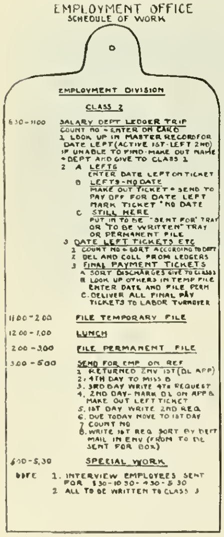
Application in Civil Engineering and Construction Fields

The term Science of Management was coined by the editor of Engineering and Contracting and first used in "Cost Analysis Engineering" (1908) and explained more fully in "Cost Keeping and Management Engineering" (1909). The last named book, which contains ten laws of management and many subsidiary principles, was the first book on the science of management. In the columns of this journal many additional laws, principles and detail methods of management have been published. This section, which appears weekly, may be regarded as a serial sequel to the two books above named.

Standard Performance of Office Forces

Those who believe that standardization is applicable only to thoroughly mechanical jobs will do well to read the following account by Merrill W. Osgood, Methods Director, Jordan March Co., Boston, of what was accomplished in the employment department of a large department store. Mr. Merrill's article appears in "100%" for November, 1919, and follows in full.

There is no greater single factor in reducing the cost of production than standardizing the worker's job, and having individual production records. There seems to be some prejudice, however, against the application of the standardization principle to clerical forces, especially those that require initiative and more than average ability.


EMPLOYMENT OFFICE
SCHEDULE OF WORK

EMPLOYMENT DIVISION

CLASS 2

630-1100 SALARY DEPT LEDGER TRIP
COUNT NO + ENTER ON CARD
1 LOOK UP IN MASTER RECORD FOR DATE LEFT (ACTIVE 1ST - LEFT 2ND) IF UNABLE TO FIND - MAKE OUT NAME + DEPT AND GIVE TO CLASS 1
2 A LEFTS
ENTER DATE LEFT ON TICKET
B LEFTS - NO DATE
MAKE OUT TICKET + SEND TO PAY OFF FOR DATE LEFT MARK TICKET "NO DATE"
C STILL HERE
PUT IN TO BE "SENT FOR" TRAY OR "TO BE WRITTEN" TRAY OR PERMANENT FILE
3 DATE LEFT TICKETS ETC
1 COUNT NO + SORT ACCORDING TO DEPT
2 DEL AND COLL FROM LEDGERS
3 FINAL PAYMENT TICKETS
A SORT DISCHARGES GIVE TO CLASS 1
B LOOK UP OTHERS IN TEMP FILE ENTER DATE AND FILE PERM
C. DELIVER ALL FINAL PAY TICKETS TO LABOR TURNOVER

1100-200 FILE TEMPORARY FILE

1200-100 LUNCH

200-300 FILE PERMANENT FILE

300-500 SEND FOR EMP ON REF
1 RETURNED ENV 1ST (OL APP)
2. 4TH DAY TO MISS B
3. 3RD DAY WRITE 4TH REQUEST
4. 2ND DAY - MARK OL ON APP & MAKE OUT LEFT TICKET
5. 1ST DAY WRITE 2ND REQ
6. DUE TODAY MOVE TO 1ST DAY
7 COUNT NO
8. WRITE 1ST REQ SORT BY DEPT MAIL IN ENV (FROM TO BE SENT FOR BOX)

500-530 SPECIAL WORK

NOTE 1. INTERVIEW EMPLOYEES SENT FOR 830-1030 - 430-530
2 ALL TO BE WRITTEN TO CLASS 3

Fig. 1.

We have discovered in our experience that the higher type of workers are quickly "sold" the idea, they are able to see its advantages to them, as well as the organization, and are very ready to co-operate with us.

In the department store organization there is probably no division which better represents the average problem of this nature than the employment office, and in our own case, the methods used in making the time study for these jobs is typical of that used in all departments.

Before undertaking the time study and standardization in any department, we call the workers together and explain exactly what we are planning to do; we get their interest and almost invariably, enthusiastic co-operation.

All reasoning workers are glad to be relieved of distracting interruptions, to do work in the shortest and best way, to know exactly what is their particular job and to assume responsibility for it, to be freed from overtime work, and to have their "tools" in the most accessible and comfortable positions.

For a year and a half the work in the employment office had been behind, despite a splendid esprit de corps among the workers, and a loyalty to their chief which kept them night after night cheerfully pegging away after the 5:30 gong had struck.

The first step in the reorganization was to secure the individual time study covering every minute of the day, over a period of one week. (Each employe kept his or her own record sheet.)

From this record a new temporary schedule was made up used in pencil form, and subjected to readjustments over a period of three weeks. Then the permanent schedules were ready for the "works boards," and the individual production card (see Fig. 1) could be laid out.

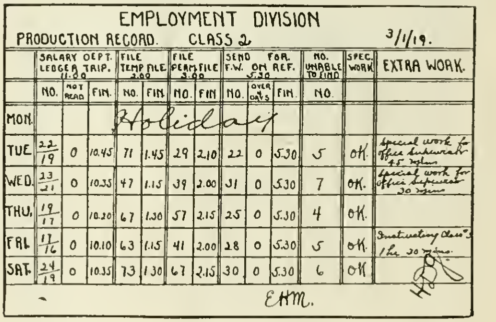
These production cards are in most cases a weekly record. The card shows the department, class number or symbol and each operation in a separate column with the "time due finished" for the operation.

These columns are then subdivided to show the number or amount of work, time started, time finished and in some cases it is necessary to show more concise information relative to the operation. When completed this record visualizes the exact condition of each person's work, whether schedules of work are being lived up to, any unnecessary extra work being done in the department and if person is entitled to bonus.

A careful study of the work of Class 2 of the employment office (see Fig. 2) will give an idea of the evolution of the standardized job from the actual time study, plus job analysis.

It was quite evident from the time study sheets that the telephone and questions were breaking into every girl's routine. We established a special operator for the department who eliminates all but certain necessary calls, and answers a host of outside phone questions, or turns the party over to the right person to handle his particaular problem.

As for the questions appearing so prolifically in the time study, they are practically abolished by the standardized job system, for every worker has his own schedule telling how, when, where his task begins and ends: and that chart once explained, the supervisor or other workers are not annoyed by, "Shall I do this? Where shall I put this? Whose basket does this belong in? When shall I tell this girl to call?"


EMPLOYMENT DIVISION
PRODUCTION RECORD. CLASS 2 3/1/19.

	SALARY DEPT. LEDGER TRIP. 11.00			FILE TEMP FILE 2.00		FILE PERM. FILE 3.00		SEND FOR F.W. ON REF. 5.30			NO. UNABLE TO FIND	SPEC. WORK	EXTRA WORK.
	NO.	NOT READ	FIN.	NO.	FIN.	NO.	FIN.	NO.	OVER 4 DAYS	FIN.	NO.		
MON.	Holiday												
TUE	22/19	0	10.45	71	1.45	29	2.10	22	0	5.30	5	OK.	Special work for office Supervisor 45 mins
WED.	23/21	0	10.35	47	1.15	39	2.00	31	0	5.30	7	OK.	Special work for office Supervisor 30 mins
THU.	19/17	0	10.20	67	1.30	57	2.15	25	0	5.30	4	OK.	
FRI.	17/16	0	10.10	63	1.15	41	2.00	28	0	5.30	5	OK.	Instructing Class 3 1 hr. 30 mins.
SAT.	24/19	0	10.35	73	1.30	67	2.15	30	0	5.30	6	OK	

EHM.

Fig. 2—Employees' Output and Accuracy Record, Weekly Summary..

This time study showed three people concerning themselves with references. Why? We could find no reason except that it had always been done. So we changed it. Now the Class 3 girl writes for all references, follows up on them, classifies them; in short all reference work is part of her job.

Note also that each girl did a share of the filing. Now the Class 2 girl is definitely responsible for it all. She keeps her files under lock and key, and has a record of "Who-takes-what" and a check on the return. And in the same way all booking has been placed in the hands of the Class 3 girl.

We saw that interviews dropped into the day's occupation at any hour; now employes sent for from various departments come only at certain definite hours, and applicant's interviews are regulated in the same way.

Does that 5 or 10 minutes wasted each morning in changing the desks around to meet the first task of the day have any significance for you? It amounted to hours in a week, but we don't do it any more.

We made a study of the desk needs and system for each girl, and as her day's work progresses the "tools" now come automatically to hand; the last job at night leaves the desk ready for the first one in the morning.

Let us add right here, that the personal pride of the workers in their surroundings and equipment is greatly fostered by the new system.

The head of the section (the Class 1 girl) is made responsible for the close adherence to the schedule and for the appearance of the section. A special bonus of $1 each week is added to her pay, when the schedule of work is O.K. and the general condition of the section is satisfactory.

From the standardized job to the understudy system is an easy step. Take the case of the three positions here used as illustrations—in the absence of the Class 1 girl, Class 2 steps up and fills her place. She has before her in black and white the Class 1 schedule, she is familiar with the department routine and methods and can carry on the day's program without a hitch.

Class 3 girl substitutes and understudies Class 2 girl; and Class 3 is understudied by a substitute supplied at once by the office training school. Things are never "left" for the absentee to "make up."

As an actual fact this understudy system works so smoothly that the employment manager would never be conscious from the progress of the daily program than anyone was absent.

The working out of a bonus system for any job from the schedule of work charts will be discussed in another issue, but it is a simple matter with this data in hand.

The result of standardization in our employment office has been a day's work finished every day; nothing piled up ahead; a busy day of concentrated work and a conscience free quitting at the closing bell; and at that, one girl is able to spend half a day each week on outside special cases.

You will find it inevitably the case, that workers are under less nervous strain, and accomplish more with less expenditure of time and energy, with standardized tasks, than under the old "hit or miss," or "habit" method.

Valuation of Speculative, Deferred and Wasting Assets

To many investors a property branded with all the attributes of the above title would appear as something to be shunned, but the fact remains that the fortunes of some of our greatest business men have been made in just this class of properties.

While it is not in a practical sense true that all assets are wasting, all are in some degree speculative and subject to deferred earnings. How many financial catastrophies have resulted from failure to recognize the presence or the importance of these factors no one knows; but that they are too often overlooked or neglected in the consideration of business commonly called "table" or "non-speculative" is fairly evident. However, it is not with this class of business, but with the class in which the elements of speculation, deferred returns and consumption of invested capital are of recognized predominance, that we are dealing at this time. Foremost in this latter class are the mining and oil businesses.

At the September meeting of the American Institute of Mining & Metallurgical Engineers at Chicago, Mr. Carl H. Beal, M. A., Petroleum Technologist, U. S. Bureau of Mines, presented a paper (published in the Transactions of the Institute) entitled "Essential Factors in Valuation of Oil Properties"; and as the principles therein set forth are very largely general in character, and applicable outside the realm of oil operations, extensive quotations from the paper are given herewith.

Factors in Oil Land Valuation.—The most important factors that should be given consideration in valuation of oil land are: (1) the amount of oil the property will produce; (2) the amount of money this oil will bring (based upon the future prices of oil); (3) development and production costs; (4) the rate of interest on the investment; (5) the retirement or amortization of invested capital; and (6) the salvage or "scrap" value of the equipment when the property is exhausted. These factors are of varying importance, and some of them may not enter all valuation problems, but most of them should be given consideration in any valuation even though only a rough estimate of the value of the property is desired.

Oil men and accountants have not generally conceded that such estimates could be made with any degree of accuracy. It has been shown, however, in several recent publications that with certain data available reasonably close estimates can be made. The accuracy of an appraisal depends chiefly on the accuracy of the estimates of future production and of the future price of oil.

The author points out that estimates of future production must be made in detail for each year that the property is expected to produce. "The future annual oil output hinges on the rapidity with which new wells are drilled and on the rate of production of the individual wells which, with very few exceptions, always declines."

". . . . on the yearly output of oil depends the yearly gross income. From the gross income the annual net return is computed, each year's return being considered in the light of a profit available at a future date. The present value of these deferred profits is then determined by discounting them at a rate of interest compatible with the risk involved."

The rate of the production of the property depends not only on the rate at which the individual wells will produce oil, but also on the rapidity with which new wells are added to the producing list; this depends on the drilling program. The valuation should not be attempted until a drilling program is decided upon. But before a drilling program can be determined, it is necessary to know the amount of land that certainly will support commercially productive wells; trustworthy estimates of future oil production can be made only for the drilled acreage and for the undrilled proved acreage. Only such land furnishes a concrete basis of value, for the annual production of oil can be estimated; other land has a speculative value that varies with the uncertainty of obtaining oil in commercial quantities. These tracts, if included, should be valued separately and on a different basis.

In valuing the proved oil land, the engineer should compute the value of the output of the property based on a drilling program that will bring the maximum return in profits to the investor. It is true that a variation in the drilling program sometimes will greatly reduce the profits eventually gained from a property, but there can be only one maximum value and this is the one to be determined.

Classification of Land to Be Valued.—Before the future annual production can be estimated, it is necessary to classify the land to be valued, to determine the amount of acreage that will support new wells. For this purpose the land is first divided into drilled and undrilled. These two classes of acreage must be valued separately.

Mr. Beal advocates refinement of calculation only to the degree warranted by data available. He says: "The undrilled oil land may usually be divided into the following four general classes: Proved acreage, probable acreage, prospective acreage, and commercially non-productive acreage. Some engineers use much more detailed classifications. These, the writer believes incompatible with the uncertainty of underground conditions.

That frequent and radical changes in value are likely is noted in the following:

"Furthermore, the classification of land may change rapidly, owing to the drilling of new wells, damage by water, or change in price. For example, an area that may be rated as commercially non-productive may become commercially productive and proved with an increase in the price of oil."

Future Price of Oil.—The accuracy of any valuation depends on the price that is to be received for the oil, for on it depends the net profit per barrel of oil marketed. A small variation in the price of oil may mean the difference between gain or loss. In fact, since the working out of new and more trustworthy methods for more accurately estimating future oil production, the estimation of the future price has become one of the most uncertain elements to be contended with in oil land valution."

The engineer, to make sound predictions as to the probable price of oil, even during the immediate future, must possess a broad knowledge of the petroleum situation as regards supply and demand. Either prices will be allowed to adjust themselves in accordance with the law of supply and demand, or they will be manipulated by monopolies or controlled by the Federal Government. If manipulation or government control exists, or if there is a strong probability of their coming into existence, the engineer should be guided accordingly.

In the paragraphs which follow, the author touches upon the necessity (common to all lines of technical endeavor, but unfortunately not always recognized) of a minute knowledge of the details and data of his profession.

"The upward limit of prices are set by the cost of importing oil and the cost of developing a supply of oil from oil shales, of which there are immense deposits in this country."

Interest on the Investment.—The basis of value in oil lands is net income. The net income for each future year of the productive life of the oil property must be estimated and these future values compared with their real values at the present moment by reducing them to present value at a given rate of interest. This is discount and is the reverse of compound interest, the factor used in the reduction of future values to present values being called the discount factor, which is a very important element in oil land valuation. By the reverse of discount, or compound interest, the future value of a present income may be determined.

Present value of a future income may be defined as that sum which, when placed at interest at stated per cent, will equal the income* at the date when it is to be realized. Thus, the longer the deferment of an income the less it is worth at the present time, for which reason one can afford to pay more for income to be obtained from the oil from a well drilled now than for the same well drilled a year hence, providing the price of oil remains constant and equal amounts of oil are produced. Furthermore, the longer drilling is postponed the less the net proceeds from the wells are worth to a prospective purchaser at the present time. Other things being equal a property should be drilled as quickly as possible, if the maximum income is to be derived from it. This may not be best from the standpoint of the public, and, if generally practiced by oil producers, would eventually work to their disadvantage.

The interest required on the investment must be high because risk is attached to the venture. Some engineers consider that the discount used in reducing future income to present value, however, should not be compounded for the reason that to compound a certain present sum to determine its future value means the first year to determine the interest on the principal and thereafter to compute yearly the interest on the principal and accumulated earnings. The rate used is a high rate because the capital, or principal, is being risked. This rate should not be applied to the accumulated interest earnings, however, because they are not risked capital. They are earnings and should be considered as such.

The computed maximum value of the property may be considerably less than what actually could be paid for the property for as the returns in the investment are realized they may be reinvested in gilt-edged securities at an accumulative rate of interest.

The Risk Element and Present Worth of a Future Income.—The error of those who consider that the present worth of a future income should not be computed on a compound interest basis at the full rate of return on the investment, apparently results from lack of definiteness in stating the manner in which the risk is to be compensated. This may be most easily explained by an example giving two different treatments of a single problem.

Take the case of a project which is expected to produce $100,000 gross at the end of a 5-year period. The risk is large. A prospective investor may say: "In view of all the circumstances this is a good investment if I can expect to double my money in the 5-year period. Therefore I am willing to invest a total of $50,000 to purchase the project and provide funds for its development. If the cost of development is estimated at $10,000, the property is then worth $40,000."

For the sake of simplicity, and because the effect would be small in amount, no consideration is here given to the possible postponement of portions of the development cost. Annual interest or return rates do not enter into the treatment just given this problem. The investor is looking upon the transaction as a unit, and it is his judgment that with the risk involved, he should double his investment in 5 years. He is not considering annual interest rates, and the fact that the return expected amounts to 20.7 per cent per annum without interest on deferred portions is purely incidental. This is an entirely legitimate method of reasoning, and one followed by many shrewd business men; albeit some of us find it easier to reason in terms of an annual basis.

Suppose, then, that another prospective investor says of this same project: "With the risk involved, I should make 20 per cent per annum on the money I put in, but the investment will pay me nothing until the end of the fifth year, when, if it is successful, it will bring me $100,000. That being the case, the 20 per cent annual profit to which I am entitled is held in the project subject to the same risks as the original investment: I have practically reinvested it, and I should earn 20 per cent per annum upon it also from the time it becomes due each year. Therefore I am warranted in investing that sum which at 20 per cent interest will amount in five years to $100,000 less the estimated cost of $10,000 for developing the property.

Since most of the expense will come in the final year (an assumption of this particular problem), a total return of 20 per cent will be approximately right for this item, thus bringing the cost of development and the return thereon to a total of $12,000.

The balance for which I am investing is therefore $88,000. The formula for the present worth of $1 to be received in n years at (r) rate of interest is: Present Worth $= \dfrac{1}{(1 + r)^n}$ so that the amount which I can now afford to pay for this project is $\$88,000 \times \dfrac{1}{1.205} = \$35,400$.

Had the second investor used the simple interest instead of the compound interest formula in computing the worth of the project, he would have found it to be $44,000.

One further phase of this subject should be noted: The total rate of return sought by the investor is divisible into two parts—interest at the "normal rate" and insurance for the risk involved, the latter parts being in proportion to the degree of risk as it is estimated by the investor. Otherwise the "normal rate of interest" does not enter the problem, and if the investor were required to introduce it into any part of his estimate he would merely vary some other factor sufficiently to equalize the effect.

The illustration that has preceded treated only of a prospective profit which was to be realized as a single unit at the end of a certain period. This might, however, represent a year's earnings, and if several such years were to be considered it would be necessary merely to take the total of the calculations for single years.

Value of a Temporary Annual Income.—An income to be received each year for a specific period, after which it ceases, may be most conveniently referred to as a "temporary income." With its conclusion the asset which produced it has been consumed—or as often expressed, "wasted." The prospective investor will usually determine a percentage of profit which he believes he should receive each year on his investment; and the sum which he will be willing to pay will be that on which the income will furnish the required percentage of return and enough more to replace, or amortize, the investment by the time the asset is consumed and the income ceases. The percentage of return will vary with the risk involved, and will generally be higher for short time than for long time investments.

For the investment of a single year, the value is determined by dividing the prospective return by one plus the rate of return expressed decimally. Thus if a total return of $10,000 is expected, and if it is considered that the money invested should earn 25 per cent, the value of the project is $\dfrac{\$10,000}{1.25} = \$8,000$.

Where the income is to continue for a period of several years, the problem is much more complicated. Still further complications arise in the case of an income which varies from year to year, and often the only solution is that afforded by computations for each year individually. For the present, consideration will be given only to equal annual incomes. The simplest treatment, and one which is often sufficiently accurate where periods are short and the factors of uncertainty are large, is that which provides for repayment of the investment in equal annual installments without allowance for interest on the repaid portion or adjustment of total annual return on the unpaid portion. The formula for this case is $A = \dfrac{E}{r + {}^1/_n}$, in which A is the value sought, E is the annual earning, r is the rate of return expressed decimally, and n is the number of years for which earnings are to continue.

The exact present value of a temporary income may be obtained by taking the total of the present worths of all the yearly incomes, each calculated separately. As previously stated, the present worth of a future earning (E) is expressed by the formula $\frac{E}{(1+r)^n}$; and the value of several such annual earnings is therefore represented by the series.

$$\frac{E}{1+r} + \frac{E}{(1+r)^2} + \frac{E}{(1+r)^3} + \frac{E}{(1+r)^n}$$

If the period is long, the value may be most conveniently calculated as the sum of the series, which is—

$$\frac{E - \dfrac{E}{(1+r)^n}}{r}$$

For annual earnings of $10,000, a rate of return (r) of 20 per cent and a period of 5 years, the present worth by this formula is

$$\frac{\$10{,}000 - \dfrac{\$10{,}000}{1.20^5}}{0.20} = \$29{,}900.$$

Calculation by the imperfect formula,

$$A = \frac{E}{r + 1/n}, \text{ gives } \frac{\$10{,}000}{0.40} = \$25{,}000.$$

Results of calculations by the two formulas will show proportionately greater differences for longer periods and less difference for shorter periods.

Frequently it will be true that the degree of risk and uncertainty is greater for the later years than for the earlier; and if the variation in risk be according to some simple law, formulas could be devised for a rigid mathematical calculation of value. But it is evident that there are few cases indeed in which the data are sufficiently reliable to warrant such refinement of calculation. Inability to obtain an exact result, however, should not be made an excuse for the substitution of a pure guess for such intelligent estimates and calculations as are possible. In particular there should be determinations of the upper and lower limits between which the value may, by any reasonable chance, lie.

Perpetual Income.—To produce a perpetual income, an asset must of necessity be non-wasting. However, the asset may be speculative, in which case its non-wasting character is presumptive instead of certain. Also the commencement of the income may be deferred to a future date, in which case the asset also may conveniently be referred to as "deferred."

If the annual income is already existant or is to begin immediately, the value of the asset is determined by dividing the net income by the rate of return (expressed decimally), which is considered appropriate to the risk involved. Thus, if a property is expected to perpetually produce $30,000 per year, but the risk is so great that an investor will demand 15 per cent on his investment, the value of the asset is $\frac{\$30{,}000}{0.15} = \$200{,}000$. Obviously if at any time circumstances develop to change the amount of income or the degree of risk, the value of the asset will also change, and there are many cases in which such revision of value is necessary.

In the case of an income which is to begin at some future date, the value of the asset is calculated by what is known as the formula for present worth of a future income: $A = \frac{E}{rq}$, in which A is the present value sought, r is the rate of return expressed decimally, q is the sum to which one dollar will amount at compound interest at rate (r) from the present time until the commencement of earnings, and E is the prospective annual net income. $\frac{E}{r}$, it should be noted, will be the value of the asset after the income has commenced. For example, suppose that the $30,000 annual earning of the preceding case is not to begin for 3 years, and that the risk is still estimated as requiring a 15 per cent net return:

$E = \$30{,}000$
$r = 0.15$
$q = 1.521$

$$\text{Present value } (A) = \frac{E}{rq} = \frac{\$30{,}000}{0.15 \times 1.521} = \$131{,}500.$$

Amortization.—The investment in a perpetual income is not generally to be amortized; and in the exceptions to the general rule, the method must be either arbitrary or dependent upon factors not now under consideration.

In the examples showing calculations of the present value of investments in temporary income, the return included both amortization and profit—that is, both principal and interest. In the case of the investment of a single individual, the separation of these items is not always a matter of importance, but with corporations which are exploiting exhaustible resources the separation of profit from amortization is often of primary importance, and may even be regulated by law. The peculiarities of particular cases and classes of cases have resulted in the development of a great variety of amortization methods—some of them good, others both unreasonable and unjustifiable.

The simplest form of amortization consists in the setting aside annually of an amount equal to the quotient of the initial investment divided by the number of years of its estimated life. This method is implied in the rough formula which gives present value $(A) = \frac{E}{r + 1/n}$; and if the amortization allowances are paid to the investors each year, it is correct. If, however, the investment is not to be repaid until the conclusion of operations, a sinking fund provision is clearly the more business-like method. Sinking fund methods will not be separately discussed here.

In the series formula:

$$A = \frac{E}{1+r} + \frac{E}{(1+r)^2} + \cdots \frac{E}{(1+r)^n}$$

each term of the series represents the investment made for the corresponding year, and is the amount which may appropriately be repaid to the investors at the end of such year. It is noted in this connection that the total profit upon the investment represented by any single term of the series—for example, the third term, is equal to $E - \frac{E}{(1+r)^3}$, and that it is computed as profit for the entire period of 3 years, with deferred portions compounded at rate (r). Amortization on this basis is entirely rational, as it provides that the investment which is made for the purpose of producing a profit in a given year shall be repaid at the end of that year, and out of the gross earnings thereof. It has the further effect of making the earlier years bear a larger burden of amortization than the later, while profits for disbursement increase yearly. This is in accordance with conservative accounting practice. If the amortization allowances were placed in a fund instead of being repaid immediately to the investors, the sinking fund factor would be introduced and would operate to reduce the amount of each year's allowance.

In cases where the earnings vary considerably from year to year it is usually desirable to adjust amortization provisions somewhat in proportion to them. This results in complications and in much variation of practice under differing conditions. Some interesting cases are discussed by Mr. Beal in the article from which quotations have already been made, and we quote as follows:

Although sinking funds may not be established, some attempt must be made to return capital uniformly and justly, where it is possible to estimate the amount of oil recoverable and the hazard of the investment is not too great to make such calculations useless.

A method often practiced by oil companies to determine the rate of retiring the capital invested in both physical property and in the resource is called the "settled production method," and consists of applying a unit value per barrel of settled daily production. The value of the property at any time is the daily production multiplied by the unit value. The difference in the value determined at any two periods is the depreciation or appreciation according to whether the value has gone down or up.

A modification of this method for the purpose of determining the depletion deduction in connection with the computing of taxable income, is called the "reduction in flow method." The method has been authorized by the Treasury Department, but obviously is unfair when it is remembered that the basis of the method depends on a reduction in the output of an oil property from the existing wells only. No depletion is allowed and, therefore, no capital is retired unless production is decreasing. If production decreases 5 per cent during the taxable year, 5 per cent of the capital invested is retired. During the next year, if the decrease is 10 per cent, that percentage of the unretired capital is "written off." As a general rule, the output of an oil property increases for a few months, at least, while drilling of new wells is in progress, and in some fields, production may increase for several years. Still, by use of this method no capital can be retired until the production of the tract begins to decrease. Production of oil means depletion of its recoverable content and every barrel of oil taken from a property exhausts it just that much, and brings it just that much nearer the end of its life. To retire no capital while production is largest and then when production begins to decline, to retire large amounts against a decreasing income not only is inequitable to the oil operator, but places the whole enterprise in jeopardy by deferring the amortization to a period when the field is rapidly approaching exhaustion and too late to cover the return of capital.

The producer has made a definite investment in each barrel of recoverable oil. If he can estimate the amount of recoverable oil, he can easily determine the cost per barrel. For every barrel of oil produced, he should retire an amount of capital equal to the original investment in that barrel of oil. This is called the "unit cost method," by which a fixed charge per barrel of oil produced, based on quantity, is assessed. It is sound in principle, not difficult of application, and has been adopted by the Treasury Department in the determination of the depletion deduction in connection with the administration of the income and excess-profits tax laws.

The basis of this method is to determine the total capital invested in the oil and then divide the estimated recoverable oil into the capital invested; the result is the unit cost. For instance, if the sum of $1,000,000 is invested in the oil under a property, estimated to produce ultimately 10,000,000 barrels of oil, the unit cost per barrel is 10 c. The producer has paid this sum for each barrel of oil under the property. If he sells each barrel of oil for $1.50, his net income for each barrel will be determined by deducting all charges from $1.50. Suppose all charges, excepting unit cost, amount to 40 c. per barrel, his net income is, therefore, $1.

Estimates of future production may be revised each year and a new "unit cost" obtained by dividing the unretired capital by the remaining recoverable oil. The amount of capital to retire during that year on account of depletion will be the unit cost multiplied by the production.

Many oil companies have adopted this system because by its use they are enabled not only to determine the depletion deduction equitably and justly, but also because they are enabled to retire the capital investment at the same rate at which the oil is produced.

Salvage Value of Equipment.—When the oil is exhausted, a certain amount of physical property will be on hand. The investment of this physical property should have been completely amortized, with no investment remaining except that which can be realized from the disposal of the equipment. This sum is called the salvage, or "scrap," value of the equipment. Ordinarily this "junk" value is not great at the exhaustion of the oil. Furthermore, the proceeds derived from the sale of the "junk" must be discounted to the time of the valuation at a certain rate of interest. Usually the property will have a life of more than 20 years, and the present value of the junk, even at a comparatively low rate of interest, is rather small when compared with other sources of income that must be present before the investment is a good one. Occasionally, the expenses in connection with the abandonment of the property, such as properly plugging the wells, will cost as much or more than the present value of the junk, so that this item in oil-land valuation is ordinarily not important.

Mental and Moral Qualifications of An Estimator

Perhaps none but novices are in danger of treating estimates as either simple or easy of preparation; but surely the task of informing the novice of today—the expert of tomorrow—is not less worthy nor even less important than that of adding to the store of information of the great man of the profession.

In "The American Contractor" of Oct. 4, 1919, the associate editor of that paper, Mr. Dudley F. Holtman, presents some points which the novice will do well to ponder, and some also worthy of consideration by the more experienced.

Disagreement with the author's statement that "wide experience with the actual supervision of work" is a necessary part of the equipment of the expert estimator, will be entered by many who have observed excellent estimating by men whose experience lay chiefly in the field of statistics, and who had not spent large amounts of time in any administrative or supervisory capacity, although probably in all cases they had had considerable construction experience in subordinate positions. We think of one engineer in particular, who not only never occupied a position of broad supervisory capacity, but was so temperamentally unsuited to administrative work that he probably never could occupy such a position. Nevertheless, the accuracy of his cost estimates was repeatedly proved by the records of completed jobs—in some instances the more conspicuously, because his estimates had been overruled by superiors.

Mr. Holtman's opening paragraph relates to the important position of estimates in engineering work.

The preparation of estimates is, perhaps, the most important function of the engineer and contractor, for it is generally the first step that he has to take in connection with any construction project. It is quite unnecessary to bring forth any statements or arguments in support of this statement. We cannot fail to appreciate the fact that this question, by its very nature, is of fundamental importance, for not only is it the first step to be taken, but unless an engineer or contractor establishes a reputation for accurate estimating it is not likely that he will be trusted with the preparation of estimates on work of any importance in the future. Upon his ability to prepare an accurate estimate of cost will often depend the very important question of whether the proposed work will materialize or not.

Honesty Will Lose Work Rather Than Make an Underestimate.—After enumerating the major classes of items of estimates, including contingencies and profit, the author continues:

In outline these are the main requirements that have to be considered in the preparation of any estimate. Judging, however, from such indications as have come to my attention, I am disposed to believe that certain mental and moral characteristics are essential for the preparation of accurate estimates.

On first thought this may seem to be rather a strange statement. Nevertheless, any one who is at all disposed to view the subject in its broader aspects will, I am convinced, realize its significance. Unless an engineer or contractor has had wide experience with the actual supervision of work he will, of course, be but poorly equipped to do responsible estimating. But there are other qualifications that he must possess. In the first place, he must have the habit of keeping in touch with prices and must be able to follow a development mentally in advance of construction. He must be able to foresee eventualities. And then accurate estimating requires that the engineer shall have the habit of general accuracy and shall be able to systematize the work so as to avoid any possibility of omitting important items. In addition to these characteristics which are, perhaps, purely mental, there are certain moral qualities which one must possess.

Though we seldom give thought to this requirement, yet we must realize its importance. The point is this: That a man must be absolutely honest and courageous if he is to successfully carry on this part of construction work. His honesty must be developed to such an extent that the desire to obtain the job will in no way influence his mind to minimize the estimated expense or to omit any items of expense that will in all probability have to be met. And then the only way to compel clients to have confidence in one's ability as an engineer or contractor is to be able to endorse every estimate unhesitatingly. In order to do this one must have the courage of one's convictions.

Care Must Be Exercised in Considering Contingencies.—A good rule to follow in preparing any kind of an estimate is not to try to round out each item of expense or to increase it to take care of contingencies. If one adds a contingent amount to each item it is more than likely that he will deceive himself in the final summation by overloading the estimate. Time spent in analyzing the amount that is added to cover overhead expense is time well spent. If the percentage added is too great the owner will think that the engineer did not know his business and that he was trying to cover his ignorance by a large allowance for the cost of the unknown. What percentage should be added to an estimate for contingencies will depend entirely upon the character of the destruction and the probable difficulties to be encountered. For instance, in the case of construction in a well-populated district where transportation facilities are adequate and where the labor problem would cut no figure, the contingency item should be small. But in the case of work where difficult foundation conditions are likely to be encountered and where the work is at a place distant from civilization a much larger percentage must be added. The percentage to be added to the estimate for contingencies should, in any case, not be determined by either guess work or snap judgment. It is advisable to go through the entire list of the items of cost and consider each one separately, so as to decide whether it contains an item of uncertainty or not. Then by adding these separate contingent items and perhaps increasing the total a trifle to take care of the absolutely unknown, a general item will be obtained that will be as nearly correct as possible.

The still greater breadth of the field is set forth by Mr. Holtman in a quotation from Mr. J. A. L. Waddell.

Discussing estimates in bridge construction, Mr. Waddell, one of the foremost bridge engineers in the country, says: "The consulting bridge engineer has many other estimates to make than those of first cost; for instance, estimates of the cost of maintenance, renewals and operations; estimates of revenue; estimates of time required for construction; estimates of how much money will be required to pay for work as it proceeds, and the interest thereon up to the anticipated date of completion; and comparative estimates of cost of various methods of construction for any projected work by taking account of the compound interest involved."

Rental Charges for Construction Equipment

In connection with the preparation of a standard list of rental charges for construction equipment a committee of the Associated General Contractors of America has been collecting information as to the practice of various contractors in this matter. In the January 10 News Letter of the association the following schedule of rental charges, submitted by an eastern contracter, is given:

Equipment.	Weekly rental.
Boiler, only, 30 H.P. and smaller	$12.00
Boiler only, 30 to 60 H.P.	16.00
Bucket, clamshell, ¾-yd.	15.00
Cars, skip, 1½-yd.	2.00
Cars, steel, 1-yd. and smaller	1.50
Crusher only, Acme No. 9½	22.00
Cutter, bar portable, with motor	9.50
Derrick, 30 to 59 ft., wooden, home made	3.00
Drill, small air	3.00
Drill, steam	4.50
Elevator, platform or bucket, 1 yd.	2.00
Engine, skeleton, 2-drum, 20 H.P.	8.00
Engine, gasoline, to 8 H.P.	3.00
Engine, gasoline, 10 H.P.	5.00
Leveling instrument, engineers'	1.50
Mixers, with gasoline engine, 11 to 15 ft. cap.	15.00
Motors, 2 H.P.	1.50
Motors, 5 H.P.	2.50
Motors, 10 H.P.	3.50
Motors, 25 H.P.	5.00
Motors, 50 H.P.	9.00
Pumps, centrifugal, 10-in., belt driven, with engine	7.00
Pumps, pulsometer, to 4-in.	6.00
Pumps, 3-in., with gasoline engine	3.50
Pumps, diaphragm, with gasoline engine	3.50
Saw benches, plain	3.00
Saw benches, plain, with motor or gas engine attached	5.50
Saw swing cutoff, no power	1.00
Steam shovels, revolving, traction, per day	24.00
Transit	2.00

In submitting the list, the contractor wrote as follows concerning his firm's policy on equipment rental:

The plant rental sheet was revised the first of this year and will be revised again for another year, probably upwards. Our rental basis for our own work is entirely that of replacement cost. All plant costing $150 or more whose life extends over a period of years or over several jobs is shown on our detailed list, which is compiled from our experience of the probable life of each tool. There are three classes:

Class A—Tools which will last through 50 weeks of continuous work.

Class B—Tools which will last through 75 weeks of continuous work.

Class C—Tools which will last through 100 weeks of continuous work.

Our rental is sufficient to produce enough revenue to make extraordinary repairs and to replace the plant at the end of this length of time.

You will find that these rentals are uniformly low because they are at cost to ourselves and apply on jobs where we are operating the plant. These plant rentals go into a cost-plus or fixed-fee contract as a part of the job cost on which profit is figured.

If we rented the plant to outsiders we would charge about half as much again for it.

Our method of handling small tools such as shovels, picks, hammers, etc., is to charge their entire cost to the job. If they are worn out they become part of the job cost. At the completion of the work an inventory is taken and each tool is appraised in co-operation with a representative of the owner. We have five grades: (1) New, 100 per cent of first cost; (2) good, 75 per cent; (3) fair, 50 per cent; (4) poor, 25 per cent; (5) worthless, 0 per cent. We take them back as per inventory.

Fuel Value of Wood.—In heating value, 1 lb. of good coal may be taken as the equivalent of 2 lbs. of seasoned wood, says the U. S. Bureau of Standards. Allowing 80 solid cu. ft. of wood to an average cord and assuming the sticks to be well seasoned, a cord of hickory or other heavy wood is equivalent in heat value to one ton of coal. For lighter woods, as cedar, poplar, spruce and white pine, 2 cords are equivalent to 1 ton of coal. Equal weights of dry non-resinous woods give off practically the same amount of heat in burning; that is, a ton of dry cottonwood will give off as much heat on burning as a ton of white oak. Highly resinous woods, like some of the pines and firs, have an appreciably greater heating value per ton, because a pound of resin gives off twice as much heat during combustion as a pound of wood. When buying wood by the cord, it must be remembered that different species vary greatly in weight per cubic foot, so that a cord of hickory has considerably more fuel value than a cord of soft maple. A cord of seasoned wood contains more wood than a cord of green wood, because of the shrinkage which takes place in seasoning. The amount of moisture in firewood influences not only the vigor with which it burns but the amount of heat actually given off. Therefore to obtain a standard cord of wood of the greatest fuel value, thoroughly dry wood of the heaviest kind, straight in growth, cut into short lengths and with the largest diameter, should be selected. As a rule, the softwoods burn more readily than the hardwoods and the lighter woods burn more readily than the heavier ones.

A Practical Blue-Print Protector.—An inventive genius has designed a very practical blue-print protector of simple construction and low cost. A sheet of transparent sheeting—the same material used for lights in auto curtains—is cut to desired size. A piece of light-weight leather substitute is then cut about ½ in. larger all around than the piece of sheeting. This extra ½ in. allows for a lap-over on all but the top side of the protector. A sewing machine stitches the lap down to the sheeting forming a large flat pocket, open at the top for the insertion of the blue prints. Both the transparent front and the coated fabric back are water-proof and grease-proof. Dirt or grease may easily be wiped or washed off either without injury to the material. Both materials are flexible and the holder may be rolled up if desired in the same way an unprotected blue print is usually handled by a workman.

Report of the Alaska-Yukon Boundary Commission

Under the convention of 1906 between the United States and Great Britain a joint commission was created for the establishment of that part of the 141st meridian of west longitude which forms the boundary between Alaska and the Yukon Territory from Mt. St. Elias to the Arctic Ocean. The report has recently been finished and certified copies have been laid before Parliament and the United States authorities.

The work done by the commission comprised in the following items:

(a) Opening a vista with a 20-ft. skyline along the boundary line through all timber.

(b) Marking the line with permanent monuments of aluminum-bronze set in rock or concrete foundations at intervals of not more than four miles, and intervisible where practicable.

(c) Establishing a belt of triangulation along the line and the geodetic positions of the monuments.

(d) Making a topographic map on a scale of 1 in 62,500 with a contour interval of 100 ft., covering a belt of country from four to five miles in width along the line.

(e) Running a line of precise levels from tidewater at Skagway to some point on the boundary line for the control of elevations.

The final determination of the starting point for running the 141st meridian was made by the telegraphic method in 1907 and checked with an astonishingly small error with some preliminary determinations made a few years previously by the method of moon culminations and star occultations. The method of projecting the line was by means of the transit with micrometer eyepiece and using heliotropes for backsights and foresights, alternate sets of observations being made by a United States and a Canadian observer.

The transit having been carefully set over the last point determined on the line, and the rear heliotrope over some other known point on the line, usually the last previously determined point, all was in readiness to determine a new point ahead. Setting the micrometer at collimation, which was easily determined by a short series of direct and reverse readings on the rear heliotrope, and transiting through, the fore-heliotrope man, who was showing his light from the ridge on which the new station was to be set, was instructed by means of the heliograph, which direction, east or west, and about how far, to move so that his light would appear about midway between the two vertical wires of the micrometer. This was usually accomplished in two or three moves, as the first move, though merely an estimate, furnished a scale by which to judge the distance between the heliotrope and the line.

The fore-heliotrope man, on being signaled that he was on approximate line, selected and marked two points about 1.5 meters apart, one on either side of the line, and set his heliotrope over one of them. The readings being completed, the heliotrope was set over the second point which was likewise read on. The distance between the two points had meanwhile been carefully measured by the fore-heliotrope man and was now transmitted to the instrument party and using this as a base and knowing the deflection angles to the two points as read by the micrometer, a simple proportion gave the position of the true line with reference to either point. This position was then communicated to the fore-heliotrope man, who measured the offset to the true line, marked the position and erected a signal in the usual manner.

Mr. J. J. McArthur, the commissioner for the British Government, under whose direction the work was completed, has summarized the report in the Journal of the Engineering Institute of Canada, from which the data in this article is abstracted. He states that—

"There can be no doubt that the completion of the work was greatly expedited by the more than friendly relations existing at all times between the parties working under the direction of the commissioners, and by the remarkable esprit de corps shown by all connected with the work. Everyone, American and Canadian, seemed to successfully grasp the idea that the work was of paramount importance, and it was advanced with the greatest possible speed consistent with good quality, often at the sacrifice of reasonable and legitimate personal comforts on the part of the men, and the disposition of one party to assist one another in every possible way was quite as apparent between Canadian and United States parties as between parties of the same nationality."

Mechanical Ballast Cleaner

Every railway maintenance engineer knows how essential it is to have rock ballast clean, especially in the winter months, as the dirt pockets accumulated during the summer freeze at that time, causing an uneven pressure on the rails. Water collects in dirty ballast in every season of the year, and causes the short-circuiting of block signals. Ballast cleaning has always been a difficult problem to the railroads using rock ballast, and there never has been a time when abundant labor could be found to do the work entirely by hand. With the acute labor shortage prevailing for the last three years, it has been almost impossible to find enough men to do the work at a wage which the railroads could afford to pay. A number of eastern railroads, including the Pennsylvania, the Baltimore & Ohio, the New York, New Haven & Hartford, the Western Maryland and the Central of New Jersey, have now adopted the mechanical ballast cleaner shown in the illustration.

Link-Belt Ballast Cleaner in Operation on Main Line of Pennsylvania R. R.

An outstanding feature of this labor-saving device is that when operating in the ditch between tracks, it does not have to be moved for passing trains, and clears all traffic safely. A compact gasoline engine mounted on the mechanism operates the machine. The early ballast cleaner now in use advances on caterpillar travelers which rest on the ends of the ties in the intertrack space, and is moved by a hand ratchet at the rear. In future machines, this ratchet will be harnessed to the engine, and the cleaner will go forward under its own power.

In operation the rock ballast is taken up by a bucket scoop, elevated and dumped into a shaking screen. The dirt goes through a tray beneath, to be shoveled off by hand, while the clean rock passes over the screen and is deposited in the ditch again. The cleaner is stated to maintain a speed of one standard rail length of 33 ft. in 45 minutes. It is claimed that the machine, with five men, one of whom acts as a watchman, does the work of ten men in less time, more efficiently and at a greatly reduced cost. In the near future the manufacturers expect to further develop the device so that one of these workmen can be eliminated, and the machine with four men will do the work of ten men safely even when operating on double-track systems.

This ballast cleaner is manufactured by the Link-Belt Co., Chicago. It was invented by Mr. H. D. Pratt, a mechanical engineer of the company.

In connection with the standard rock cleaner, an auxiliary machine is being developed by the Link-Belt Co., the purpose of which is to keep the ballest free of dust and cinders after it has been treated by the cleaner. This device will be mounted on a standard gage truck, and a suction mechanism will be operated by a large fan on much the same principle as the vacuum cleaner. The suction cleaner will take up loose particles of dirt to a depth of 6 in. below the surface of the rock ballast.

Open Cut Blasting Accident from Missed Holes

Accidents caused by missed holes occur, both underground and in open cuts. Many of them are avoidable and attention to the details of such accidents should make it easier to avoid them in the future. The following report of an accident, occurring in some open-cut steam shovel work, in which two men were killed, should serve as a warning in operations where any uncertainty exists about a missed hole and where black powder is being used. The accident referred to occurred in an open pit copper mine in Utah, and is described as follows in the December Reports of Investigations of the U. S. Bureau of Mines:

The height of the face at the cut is about 30 ft. Twenty 1¼-in. vertical holes 30 ft. deep were drilled at the time and chambered with about 50 sticks of 1⅛-in. dynamite. After this, they were loaded with 8 or 10 cans of black powder in each hole, and exploded with an electric battery. The debris was then being removed by a large steam shovel. At the time of the accident the dipper was working on the right side of the cut, the boom being turned to the right. The engineers and cranemen were in their places, both being on the right-hand side towards the shot. When the dipper was just starting at the grade, to take a load, a flash was seen, followed by an explosion a few seconds later. Most of the men ran under the shovel; two or three did not quite get out of danger and were slightly hurt. The positions of the engineer and cranemen were such that there was no chance for them to escape. The engineer's body was found lying on the cab floor, and the craneman's body was found between the cab and boom beam, both being killed by the fall of blasted rock.

This seems to be a clear case of a missed hole, exploded by sparks from the steel dipper. One of the pitmen said they saw a flash and all ran for the shovel.

The formation at the surface is full of cracks and crevices. Also the springing of the holes would naturally open cracks. The explanation of the cause of the accident is that, when loading the black powder, some of the powder ran down one or more of these cracks and filled a small opening not far from the loaded hole, at the same time leaving a trail of powder from one point to the other. This explains the lapse of time between flash and blast. Sparks from the dipper just as it reached the powder caused the trouble.

The foreman and the pitmen all say they had often seen unexploded black powder in small quantities among the rocks, but that no flash had been seen before; also that this was the first missed hole they have known of, though most of these men have been on the job only a month or two.

This accident emphasizes the necessity of careful search of any place where blasting has been done for evidence of missed holes. In the cases where black powder is used the injection of water would serve as an effective preventive of an explosion.

Computing Cross-Section Areas by the Method of Co-ordinates

Mr. J. A. McDonald, Provincial Land Surveyor, writing in the Canadian Engineer, remarks that in spite of its simplicity the computation of areas by the method of co-ordinates is not often practiced by engineers. The method, of course, is not new, as text books on surveying give the identical general formulas for land areas by co-ordinates as Mr. McDonald develops in his article, and the method may be adapted to cross-section areas with little trouble. In railway or highway work the cross-section is considered as an area all of whose co-ordinates are known; the cuts or fills are represented as ordinates and expressed in terms of y and the distances out from the center become abscissal and are expressed in terms of x.

When making use of this formula, it may be advisable in figuring the first few sections, to draw rough sketches of the sections in order to ensure taking the points in correct order; a very little practice will enable an engineer to compute the areas directly from his cross-section notes.

The following directions should be followed:

Begin at any point on the section and proceed in either direction (clockwise or counter clockwise), multiplying each cut (or fill) in its order by its horizontal distance between the point just preceding and the point just succeeding. In cases where one passes to the right in measuring the horizontal distance from the preceding to the succeeding point, the product obtained by multiplying this distance by the cut (or fill) at the intermediate point is of one sign, and in cases where one passes to the left, it is of the opposite sign. Take one-half the difference between the sums of the products of opposite signs, and the result is the area of the section.

Thus, in a side-cut where only the slope stake reading and the intersection of the earth surface with the grade-line are taken, the area is a simple triangle, and the application of the formula to the computation of the area would seem to require three multiplications.

Two of the points, however, are on the grade-line and the cut (or fill) is zero, hence the product is zero; the formula, therefore, results in a single multiplication and taking one-half the product of the cut and width.

In the case of the so-called "three points" or "three level" section, which is a section actually containing five points, two multiplications are eliminated in a similar manner.

The outside slope points can be worked together by taking the sum of these cuts (or fills) and multiplying by one-half the width of the roadbed.

Depreciation of the Electric Railway Dollar

Mortimer E. Cooley, Dean of the College of Engineering, University of Michigan, gave some interesting figures in his testimony relative to the valuation of the physical property of the Public Service Railway, in a hearing before the New Jersey Commission concerning some fare cases. These cost data we reproduce from the Electric Railway Journal as follows:

These data were designed to show the change in the purchasing power of a dollar and, in view of the large number of fare petitions now pending over the country and the need of publicity on the subject of railway costs, are of special interest at this time. In the foregoing table the items under the column headed "1910" represent the costs in 1910 of that amount of the several materials which could be purchased for $100 in 1918.

Item.	1910.	Item.	1910.
Poles and ties	$41.50	Galvanized sheets	$56.00
Steel rails, heavy Bessemer	51.00	Electrolytic copper	52.50
Steel rails, light	41.00	Copper wire	55.00
Soft steel bars	52.00	Lead	62.00
Steel beams	51.00	Tin	38.00
Structural beams	58.00	Cedar poles, New York	43.00
Pig iron, Lake Superior charcoal	52.00	Cedar poles, 6-in. top, Michigan	26.00
Pig iron, foundry	58.00	Ties, white oak, St. Louis	54.00
Cast iron pipe, 6-in	45.00	Ties, yellow pine, New York	57.00
Wire nails	53.00	Machinists' wages	64.00
Wire rods	57.00	Common labor	68.00
Galvanized iron wire	49.00	Carpenters' wages	72.00

In the following table the cost of lumber at the mills is compared on the same basis as the materials in the previous tables.

Kind of lumber.	1910.	Kind of lumber.	1910.
Oak	$61.50	Douglas fir	$55.00
Maple	62.50	Hemlock	57.00
Ash	62.50	Yellow pine	48.00
Beech	54.25	Spruce	60.00

A little study of the table shows, as was brought out in the testimony, that the American dollar of 1918 "had a purchasing power about equal to the Mexican dollar of 1910."

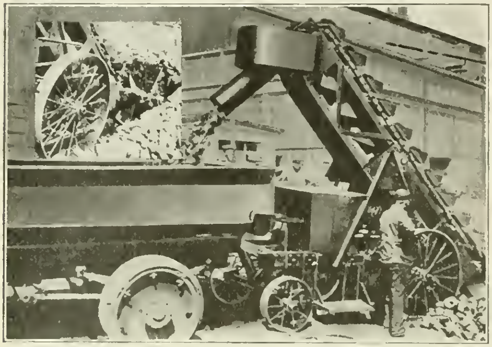
A 2,000-Year Old Definition of An Engineer

In a recent address before the Western Society of Engineers, Mr. John W. Alvord, past president of the society, gave a definition of an engineer made by Marcus Vitruvius, who wrote 150 years B. C.

"He should be a good writer, a skillful draughtsman, versed in geometry and optics, expert at figures, acquainted with history, informed on the principles of natural and moral philosophy, somewhat of a musician, not ignorant of the sciences, both of law and physics, nor of the motions, laws and relations to each other of the heavenly bodies. * * * Moral philosophy will teach him to be above meanness in his dealings and to avoid arrogance. It will make him just, compliant and faithful to his employer and what is of highest importance, it will prevent avarice gaining an ascendency over him, for he should not be occupied with thoughts of filling his coffers, nor with the desire of grasping everything in the shape of gain, but by the gravity of his manners and a good character, should be careful to preserve his dignity."

Loading Brick and Debris with Self-Feeding Wagon Loader

A self-feeding, self-propelling wagon loader was employed at the Burlington, N. J., plant of the U. S. Cast Iron, Pipe & Foundry Co., in the difficult task of loading brick and debris from a cupola which the company had demolished. The accompanying illustration shows the nature of the material handled. The machine, a Haiss path-digging loader, is driven by a 10 hp. gasoline engine. The swivel spout attached to this loader is so designed that it can be swiveled 180° and allow the material to be discharged on either side of the machine, as well as in the front.



Wagon Loader Handling Brick and Debris.

Inset shows how the paddles dig a path, clearing the material away from the wheels, so the machine can propel itself back into the material.

The loader is also used for other work around the plant such as handling coal, ashes, sand, etc.

Handling Heavy Track Material by Machinery

In a paper on the above subject before the Roadmasters' and Maintenance of Way Association convention in Chicago, Mr. J. B. Baker of the Pennsylvania R. R., gave numerous illustrations of the rapid and economical handling of track material with power devices.

Heavy rails are unloaded from cars with an air-operated derrick and boom with rail hook, the air being obtained from the train line. With this arrangement a crew of 6 men is found to be ordinarily efficient.

Ties, frogs and switches, when distributed by a work train, may be handled by a rail loader, including a hook which will unload from an open car and release in mid air. For unloading ties in storage yards, power-operated davits set in the car stake pockets and fitted with hooks and chains have been found to be economical. The use of a trolley hoist on a light I-beam is suggested for unloading from box cars, one end of the I-beam being clamped to the roof, the other end extending through the doorway of the car and supported by an A-frame on the ground outside. An overhead lifting device suited to the nature and volume of the work is necessary in the handling of frogs and switches in and out of cars.

Rail-laying machines are considered economical where it is possible to have the use of the track for several hours at a time. A small hand-operated rail layer consisting of a carriage and boom tracking on the opposite rail from that being installed, and lifting the rail by hand winches has been found to be an excellent device. With some of the heaviest rail this small machine with 5 men did the work of 20 men using ordinary rail tongs. When the old rail is thrown out several rail lengths of the operation, the new rail may be set in by the machine at the rate of about a rail per minute, and while this is usually no faster than when done by a competent gang of men with tongs, fewer men are needed with easier work for the men. With this operation it has been found economical to apply a pair of splices to the far end of each rail, held together by only one bolt loosely applied.

Railway men are coming to realize more and more the possibility of effecting economies with power devices, partly on account of the insufficient supply and high cost of labor, but quite as much on account of the increasing weights of parts of railway track which require considerable handling.

Personals

Allan B. Cullimore of Delaware College has been appointed director of the Newark, N. J., School of Technology.

Col. Lansing H. Beach, U. S. Corps of Engineers, has been nominated to be chief of engineers to succeed Maj.-Gen. William L. Black, retired.

E. W. McCoy and **J. E. Hammond** have opened offices at 801 Brunson building, Columbus, O., and will engage in a general engineering practice.

The Edmund T. Perkins Engineering Co., consulting and supervising engineers, specialists in land reclamation, has centralized all its branch offices at 38 South Dearborn street, Chicago.

Thomas L. Wilkinson, Denver, Colo., consulting engineer and secretary and general manager of the Intermountain Railway, Light & Power Co., has been appointed regent of the State University of Colorado.

John H. Walker, of Clark's Summit, Pa., has been appointed chief of the bureau of inspection of the Pennsylvania State Department of Labor and Industry. Mr. Walker was formerly on the engineering staff of the Union Pacific and Delaware, Lackawanna & Western railroads.

Industrial Notes

R. N. Woolley, who has been director of publicity of the Society for Electrical Development, Inc., for the past two years, is now with Thos. F. Logan, Inc., Advertising Agency, New York City.

Arthur Elliot Allen has been appointed district manager at New York for the Westinghouse Electric & Manufacturing Co., to succeed Edward D. Kilburn, who has been elected vice-president and general manager of the Westinghouse Electric International Co.

The Chicago Pneumatic Tool Co. announces the appointment of C. E. Laverenz as special railroad representative, attached to the staff of manager of western railroad sales, with headquarters in the Fisher building, Chicago. Mr. Laverenz for several years was an inspector in the Ordnance Department of the United States Navy and previously held positions as boilermaker and foreman of the Chicago & Northwestern and Illinois Central Railroads.

A contract recently signed between the Fairbanks Co. and the Lincoln Electric Co. of Cleveland, O., gives this company the exclusive distribution of Lincoln electric motors for industrial applications. This line includes alternating current motors for two-phase and three-phase circuits in capacities from ½ to 500 HP., for all commercial voltages and frequencies, and direct current motors from ½ to 150 HP. The Fairbanks Co. will also co-operate with the various Lincoln district offices in connection with the sale of the manufacturer's other products.

The Milwaukee Corrugating Co., Milwaukee, Wis., has let the contract for its new factory building, which is to be located at Kansas City, Mo. It is to be of reinforced concrete, fireproof construction, 385 feet long, 160 feet wide, two stories high, and will cost $250,000. The Bliss Construction Co. was the successful bidder. The time set for the completion of this new factory building is June 1, 1920. The firm now has its warehouse and salesrooms at 911-925 West Eighth street, Kansas City, which are under the management of H. H Seifert, formerly of the Milwaukee office.

The Combustion Engineering Corporation has enlarged its facilities for handling business in the Philadelphia territory. The office of the company in this territory is located in the Lincoln building, and W. C. Stripe, formerly of the Pittsburgh office and formerly of the Westinghouse Co., becomes manager of the Philadelphia district. Associated with him in that territory on the active selling force are C. L. Bachman, recently returned from active military service abroad, and who was formerly manager of the Chicago office of the Combustion Engineering Corporation before the war, and E. F. Kuehnle, formerly of the main office in New York.

The Chicago Pneumatic Tool Co. announces the appointment of Edward A. Woodworth as special representative attached to the staff of manager of western sales, with headquarters in the Fisher building, Chicago. Mr. Woodworth has been for several years secretary of the Committee on Standards, United States Railroad Administration, Washington, D. C. Prior to his engagement in the government service he was associated with the Oxweld Railroad Service Co. and O'Malley Barre Valve Co. He was formerly chief clerk to the general mechanical superintendent of the Chicago, Rock Island & Pacific R. R. and has had earlier experience in the shops of that road as a mechanic.

The Indiana Limestone Quarrymen's Association, with headquarters at Bedford, Ind., in anticipation of a year of unprecedented building, has recently been reorganized and expanded with a view to increasing its facilities for serving the architects, construction engineers and building contractors. The personnel of the association has been increased and several important appointments made. H. S. Brightly, formerly of Chicago, becomes secretary. George B. McGrath has been transferred from Washington, D. C., and is now in charge of the Metropolitan Service Bureau at 489 Fifth avenue, New York City. C. Roland Yanson has been transferred from Bedford, Ind., and placed in charge of the Chicago Service Bureau at 231 Insurance Exchange, Chicago. E. E. Miller, with headquarters in Philadelphia, succeeds Mr. McGrath as field representative of the association in the Atlantic states territory, and W. S. Whyte, with headquarters in Bedford, will cover the middle states territory, succeeding Mr. Yanson. The association's activities in the western field will continue under the supervision of J. R. Sargent, with headquarters in Topeka, Kans. Mrs. C. L. Walters has been promoted to the position of secretary of the Bedford Stone Club Auxiliary and C. H. Badgley of Toronto, Can., will act as manager of the Canadian organization.

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The four rotated special monthly issues and 4 quarterly issues of E. & C. (52 in all) entirely cover the civil engineering and contracting field at $3.00 a year. The special quarterly issues relate entirely to foreign engineering and construction practice. The *articles* in the first two issues of each month completely cover the municipal engineering and contracting field. The *articles* in the first and fourth issues of each month completely cover county engineering and highway engineering and contracting. The *articles* in the 3rd and 4th issues of each month completely cover steam and electric railway location, design and construction. See the "masthead" on the first page of the Weekly News Section for information about our weekly contract news.

Roads and Streets—1st Wednesday
(a) Roads
(b) Streets
(c) Street Cleaning
(d) Municipal Miscellanies
(e) Management and Office System

Waterworks and Hydraulics—2nd Wednesday
(a) Waterworks
(b) Sewers and Sanitation
(c) Irrigation and Drainage
(d) Power and Pumping
(e) Management and Office System

Railways and Excavation—3rd Wednesday
(a) Excavation and Dredging
(b) Rivers and Canals
(c) Quarries and Pits
(d) Railways, Steam and Electric
(e) Management and Office System

Buildings and Structures—4th Wednesday
(a) Buildings
(b) Bridges
(c) Harbor Structures
(d) Miscellaneous Structures
(e) Properties of Materials
(f) Management and Office System

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E. & C. Index Furnished Only on Request

The Index for Vol. LII—July-December, 1919—issues of Engineering and Contracting is now being prepared. In common with many other publishers we have adopted the practice of sending the index to only such subscribers as request it. Therefore, if you want the index for the last 6 months you should notify us at once. Those who requested the index for the previous volumes have been listed and need not notify us again.

The Danger of Excessive Standardization

An article in one of our recent issues discusses "standardization," going at some length into its economic advantages. Only two disadvantages are given, namely, that standardization (1) limits choice on the part of the purchaser, and (2) limits efforts to make pleasing designs on the part of the producer. There is, however, an economic loss from excessive standardization that is not easy to estimate but that is certainly enormous when summed up for a long period of years. We refer to the loss that results from lack of rapid progress where standardization has become well established. Standardization always effects immediate savings, but it also tends to restrict changes and thus to lessen progress through invention.

We need make no extensive survey of industrial development to see the stagnation that follows excessive standardization, as well as to see the remarkable progress that is common where standardization is conspicuous by its absence. Contrast, for example, the three leading modes of transportation, (1) by steam railway, (2) by electric railway, and (3) by motor vehicles.

The first named has been almost standardized to a Chinese condition of unchanging repetition. The second named is beginning to enter that era of its evolution. Whereas the third named is still improving at a tremendous stride. It will be said, of course, that every new industry is like a baby, naturally growing rapidly and changing with equal rapidity. But such similes are misleading. In science, whether pure or applied, growth should cause more growth, and change should generate more change. Invention, if unhampered by standardization or other obstacles, begets more invention; progress creates still greater progress. Viewing industry as a whole, we see that this is true. But when we turn our attention to individual industries we witness a seeming exception to the general rule that change begets still more rapid change. Why? Standardization and legislation.

In a broad sense legislation is itself a form of standardization, a molding of human action to standard forms. In the public utility

28 Pages=40 pages

The 28 pages of articles in Engineering and Contracting contain as many words as 40 pages of the size and typography commonly used by other engineering periodicals. Ours is the same size of type and type-page as that of The Literary Digest—easily read, yet giving a large volume of reading matter per page. Our 28 pages of articles would fill 112 pages of the standard 6x9 in. text-book. It would take 10 such books of 580 pages each to hold all the articles printed each year in Engineering and Contracting, to say nothing of our weekly construction news.

field legislative restrictions have served to limit progress to an alarming extent.

Many a railway prides itself upon its standard bridge and building designs, designs that were undoubtedly economic at the time they were made, but that either have actually ceased to be economic, or would have ceased to be economic had enough inventiveness been at work to make them so. A few years ago the editor, in the course of his appraisals, had occasion to study many "standard" railway structures, not a few of which were obviously out of date. In one case cut stone masonry was the only "standard" for arch bridges and large culverts! In many a case, plain concrete designs were "standard" where reinforced concrete was clearly preferable.

We have no doubt that a thorough overhauling of "standard" structural designs in railway offices would disclose a really startling lot of uneconomic designs. And after all obsolete designs had been brought up to date by a committee of the best structural engineers in America, we believe that they themselves could continue to improve the standard designs every year. Why not? Has structural science come to a halt? Will it ever come to a halt? Not unless all structural engineers are thoroughly anesthetized by standardization.

Why Economics Should Not Be Used As a Synonym for Political Economy

Writers and teachers of political economics are accustomed to use the word economics as if it were a synonym for political economics, when, as a matter of fact, political economics is only a branch of economics. It is to be hoped that engineers will oppose this practice, for not only does it tend to give an exaggerated importance to one branch of economics—politics—but it tends to make the average student of political economy think that he is learning all the fundamentals of economics when he is not.

In our last Structural Monthly issue, Dec. 24, we reprinted a paper by Prof. George F. Swain in which he said:

> The best training for the study of economics, I think, is a training in science, so that demonstration may be distinguished from hypothesis, and truth recognized when found. A subject on which opinions differ widely, while few can be demonstrated to be correct, does not appear to be a good one for an immature and untrained mind, though it may be a very useful subject of study for a mind already trained in logical methods, and with experience as a guide. Personally, I believe that the excessive study of economics in our colleges, and the turning out of large numbers of young men who have "specialized" in this subject, and who go out into the world thinking they know all about these great questions, though totally without practical experience, and without training in scientific methods of investigation as well, is one of the most serious menaces to our country. You cannot experiment by the scientific method in economics, because you cannot vary one element only. There are always many elements, the relative influence of which cannot be measured. After a young man has studied science thoroughly, has learned the scientific method, and has acquired the scientific attitude of mind, it is time for him to study, in detail, the great questions of economics, and not till then.

From other parts of his paper it is evident that Prof. Swain does not regard economics and political economics as being identical. He speaks of certain branches of economics, e. g., accounting, business management, cost analysis, as being fit subjects for engineering students to study. But there is danger that the above quoted paragraph may be misunderstood, because he uses the word economics without qualification. We agree with Prof. Swain that present methods of teaching political economics to college students are apt to beget false methods of investigating and thinking, as well as bumptiousness.

On the other hand, it does not seem to us impracticable to teach political economy in a scientific manner. Indeed we look to engineers to develop a real science of political economics, as they have already developed a science of engineering economics, and by precisely the same methods. Nor, once political engineering has been developed by engineers, do we see any good reason for not teaching it to engineering students. In fact we conceive political economics to be so closely interwoven with engineering and industrial economics that it should be taught with them, or at least immediately thereafter.

We note that Prof. Swain apparently agrees with John Stuart Mill as to the impracticability of experimenting in political economics, for Prof. Swain says: "You cannot experiment by the scientific method in economics, because you cannot vary one element only."

Similarly Mill says, in his Logic: "The first difficulty which meets us in the attempt to apply experimental methods for ascertaining the laws of social phenomena, is that we are without the means of making artificial experiments." Hence Mill infers that "the science of society must necessarily be deductive," the deductions being based on generalizations relating to human character.

We regard this as being an erroneous inference, the error springing from Mill's failure to see that small scale social experiments can be made without embracing an entire nation. Throughout his argument to prove that political economics must ever remain purely deductive, Mill tacitly assumes that no experiment could be conclusive unless it were nation wide, and that a nation-wide experiment would not itself be conclusive because proper weight could not be given to all the factors.

In our opinion Mill's dictum has done more to retard the development of a science of political economy than can be estimated. His reputation as a logician and as a writer on political economy has served, for nearly 70 years, as a bulwark against attacks upon the theory that political science can not be built upon experiments. Yet, in the face of his authority every political thinker repeatedly appeals to the results of political experiments. Witness the frequent citation of the economic results in cities that are experimenting with the "city manager" form of government. Consider also the citations of alleged economic failures and successes of municipal ownership experiments.

It is not our present object to discuss experimental politics, but we believe that an unanswerable case can be made out in its behalf. Although every factor is not under the control of those that make a given political experiment, it does not follow that such an experiment is meaningless. Even Mill would be forced to concede that much, for he recognizes, in his Logic, the significance of data based on averages; and no more is needed to overthrow his generalization that social experimentation is futile.

Are You a Trained Observer?

There is a world of difference between casual observation and systematic, purposeful observation. A careful scientific observer can learn more in a few months about a given subject than the average man learns in a lifetime about it. The difference lies mainly in two factors: (1) The relative concentration of attention, and (2) the analysis and comparison of data.

In our December structural issue we abstracted a paper by Mr. Ernest Coxhead on "Training the Architect by Direct Method." One of his most suggestive statements was this:

> The power to visualize architecture is not to be developed to any extent merely by seeing things, or by gaining fleeting impressions, but by observation, focused and concentrated upon the object in general, and in detail, by actual contact with the building and by means of measured drawings and sketches and notes, further impressing upon the mind the observations made. The essence of the direct method then lies in taking the student to architecture and confronting him with it in three dimensions, life-size, as opposed to the atelier method of focusing his attention upon mere documentary representation of the actual building. In the latter case his sense of scale is undeveloped, his ideas of proportion remain distorted, and, by laborious mental effort, he sometimes is able to construct in his mind from the documentary study of plan, elevation, and section what the subject of study, or something akin to it, is in the reality.

Mr. Coxhead is emphasizing the "direct method," or the "field work method," of training architects, with particular reference to developing a sense of proportion. We quote him, however, for another purpose, namely to emphasize the value of "observation, focused and concentrated upon the subject."

When an engineer is asked to state his experience in a given field we are all prone to give undue weight to the number of years of his experience. Rarely do we undertake to measure the degree of his concentration of observation during those years. Yet without concentration of observation, mere personal presence among suitable surroundings adds little to any man's knowledge. During the last 200 years men have learned more about natural laws than during all the countless centuries before, not because modern man has a better brain than his ancestors but because he has employed better methods of studying nature. In like manner a well trained young engineer may learn more in 10 years than an ill trained engineer has learned in 50.

More and more do educators realize that their main functions are, first, to arouse ambition, and, second, to instill lasting habits of carefully observing, reading and reasoning. It seems to us that engineering societies should also endeavor to strengthen such habits. To this end it will be wise to have classes in scientific observing, classes in systematic reading, classes in memorizing, and classes in logic. Call them classes in applied psychology, if you please, to differentiate them from classes whose main object it is to impart information rather than to develop mental habits.

It does not suffice to know what to do and how to do it. Men must be habituated by long practice, usually under mental trainers, to act in accordance with the principles to which they readily give lip service.

Preservation of Egyptian Obelisk in Central Park, New York City

To the Editor: My attention has been called to an article published in your paper, Dec. 10, 1919, and widely quoted, in reference to the condition of the Egyptian obelisk in the Central Park, New York City, known familiarly as "Cleopatra's Needle."

This article, if you will pardon me for saying so, is full of misstatements and is entirely wrong in its conclusions. The facts are as follows:

The obelisk was transported from Alexandria, Egypt, to this country and erected in the Central Park, in 1881. In 1883, fears were expressed as to its condition, but while admission was made that the stone was crumbling, it was estimated (from false reasoning) that it would take 5,000 years to remove 1 in. from its surface. In 1885, pieces commenced to fall from the shaft, and the falsity of the calculation of 1883 was demonstrated. The obelisk was then examined and found to be in a deplorable condition. To remedy and prevent further damage, Dr. R. Ogden Doremus, after a long series of tests and a visit to England to consult with authorities there who had charge of the sister needle on the Thames embankment, recommended that my father, the late Robert M. Caffall, be given a contract to apply a paraffin wax compound to the entire stone. This was done in November 1885, I being employed to assist him in the work. So much damage had been wrought by frost and rain action that no less than 780 lbs. of loose flakes and particles fell from the shaft and could not be saved. There were 20 sq. ft. of flakes preserved in place varying in size from 3 in. square to the largest 18 in. by 12 in. by 4 in. thickness at the base. So that photographs of the stone taken subsequently showed a variation from photographs taken at the time of its erection. It is important to bear this in mind, for in 1912 a photograph of the obelisk was taken and compared with a photograph of 1881, and the discrepancy between the two was made the basis of an alarming article in another paper to the effect that the obelisk was falling to pieces. In 1890 an examination of the obelisk was made by a committee of eminent scientists nominated by the Park Commissioners, and this committee expressed satisfaction at the sound condition of the obelisk, but suggested a special treatment for the loose flakes, that they should be subjected to a saturation with hot paraffin compound by hydraulic pressure in order to insure a thorough penetration of the wax, lest some moisture should get behind a flake and force it off. This was done in 1893 and a gilded zinc cap was placed on its apex in order to make the obelisk an absolutely complete specimen of obelisks as the egyptians saw them.

The committee recommended that a periodic examination should be made every 10 years so that if any weakness or flaking should have developed, that part might receive a retreatment of the paraffin process for its preservation. In 1913, owing to a misapprehension of its condition the obelisk was scaffolded and I was permitted to examine the entire surface. I took two days to make the examination, going over every inch of its surface. A flake as big as one's thumbnail had fallen, probably due to a stone thrown by a mischievous urchin, otherwise the obelisk was in absolutely perfect condition, sound and hard as bell metal.

The Commissioners permitted a coating to be applied with a brush, of the material that had been furnished free to them, but it had no penetrative action, for it did not dissolve paraffin. It has since been washed off by the weather. Today the obelisk stands sound and perfectly protected by the paraffin applied in 1885 and 1893.

EDWARD M. CAFFALL.

New York.

"Why Do Most Practicing Engineers Study So Little?"

To the Editor: The editorial "Why Do Most Practicing Engineers Study So Little?" in your Oct. 29 issue, propounded a question over which I have often thought without coming to a satisfactory conclusion. It occurs to me that one reason is a natural reaction from the time, a half century ago, when the available reading material was so small that an interested man was apt to devour everything in sight, to the present when there is so much written that one is so confused in selecting the things really worth while that only the most persistent will continue, and the average man will turn to the movies or other later developments for diversion.

Some men read too much these days; that is they spend their time in trying to decipher what some one else has thought or done rather than exercise their own brain in developing something themselves. It is no easy matter to strike the happy mean but I believe your efforts in the editorial in question and elsewhere will help many a man to find himself.

It would be interesting to know what proportion of the known readers are college men and helpful perhaps if records could show comparative attainments of those who read systematically and those who do not.

I believe the crowded curriculum has exerted an unsatisfactory influence upon the present situation and that the current discussion through the Mann report and elsewhere will have some influence in correcting it. In the more or less determined effort which I have made to get our men to acquire inspiration and facility in searching for data I can claim no really satisfactory results. The emphasis you have given in preparing this editorial will help me because I shall discuss this with my classes.

ALMON H. FULLER,
Professor of Civil Engineering, Lafayette College.

To the Editor: The editorial is justified by the facts and is written with moderation.

I am conscious that the majority of our students, when they come to the senior year and even during the several years following graduation, seem to be immersed in routine work and do not look over the fence. That is a defect in our method of teaching in college. Most of the engineering courses are taught in a systematic way, starting with abstractions and later making individual applications of principles that have been developed. I find that it is only when a student is given a particular job that interests him that he has the initiative to search through the files of engineering literature and books in the library.

It appears to me then that the condition exposed in your editorial can be corrected by a better mixture of the standard methods of study, and the so-called "situation method." In relation to the latter, I think that you will find a good exposition of the "situation method" in a report recently published by the War Department entitled "The Engineer School at Camp Humphreys."

W. K. HATT,
Professor of Civil Engineering, Purdue University.

General Chemical Company's Construction Plan.—The General Chemical Co. has entered into a contract with the J. G. White Engineering Corporation, New York, covering the future designing, engineering, and construction work incident to improvements and extensions to existing manufacturing plants, buildings, and other property, and in connection with any new projects or developments which may be undertaken from time to time. Under this arrangement, the J. G. White Engineering Corporation will handle their engineering and construction work. Two initial pieces of work, which are to be carried out immediately under the new arrangement, are the construction of a large warehouse at Pittsburgh, and improvements to the company's Delaware works near Marcus Hook, Pa.

Automatic Induction and Deduction

By HALBERT P. GILLETTE, Editor.

It is generally conceded that any practitioner is made better by knowledge of the theories upon which his practice is based. Thus, a draftsman is better if he understands geometry, a repairer of gasoline motors is better if he understands certain theories of mechanics and of internal combustion engines. For the same reason a thinker becomes a better thinker by understanding the processes of thinking.

About 48 years ago Herbert Spencer, the father of evolution, published his Psychology, in which, for the first time, an attempt was made to trace the evolution of the brain and its functions. Unfortunately, however, Spencer was not able entirely to free himself of methods of thinking that tend to obscure the truth. At the very beginning of his discussion of the process of deductive reasoning he departed from his plan of tracing its evolution. Instead he announced a plan that was precisely the opposite of advancing from the earlier and simpler to the later and more complex; and on page 4 of his second volume, he said:

"An analysis conducted in a systematic manner must begin with the most complex phenomena of the series to be analyzed. After resolving them into phenomena that stand next in order of complexity, it must proceed similarly with these components; and so, by successive decompositions, must descend to the simplest and most general."

This method of working backward from the most complex to the simplest may be safely adopted only when there exists, at the inception of the analysis, a very complete understanding of the simplest elements; but such an understanding Spencer did not possess. Starting, therefore, with one of the most complex processes of volitional deduction, he failed to arrive at an understanding of the simpler process of automatic deduction.

It is not to be wondered that his predecessors had similarly failed, because lacking understanding of the theory of evolution, they never even looked for such a thing as automatic deduction. In fact, they began by denying that animals could reason either inductively or deductively, and therefore ended by failure to understand the fundamental nature of induction and deduction.

Steffensen, the great Arctic explorer, tells in one of his lectures a story to illustrate how preconceived opinions blind men to the most obvious facts. A ship was wrecked off the eastern coast of South America, and its crew floated for several days on rafts without food or drink. When a rescuing vessel reached them their first cries were for water. "You blamed fools," shouted the captain to them, "you are floating in the Amazon river. Get down and drink." They had been nearly a week in a saltless ocean, made by the Amazon river in its hundred-mile flow beyond the coast of Brazil. Based upon the false premise that all water in the area of the seas is salt, those poor sailors had inferred it to be suicidal to drink of the waters about them, nor had it even occurred to them to test the truth of their major premise. In like manner, logicians have invariably refused to believe that any living creature except man could reason. Where they saw what seemed to be evidence of deduction by animals, they refused to credit the evidence; and they even set about destroying the evidence. The most effective way to do this has ever been to invent a name or term to apply to the fact that one seeks to discredit. So the early philosophers and logicians invented the name "instinct," under which they classed what I shall term automatic thinking. This name (instinct) served to divert attention from the thinking processes of animals. The word "instinct" thus came to designate a mental process believed to be wholly different from "reason."

Similarly when it was observed that many people often arrived at correct conclusions at a glance, the name "intuition" was coined, which also served to blind the eyes to the fact that there was such a thing as reasoning involved in the process.

Names, as will be fully explained in a later article, have not only been made to serve as the cloak of ignorance but as the shrouds of dead ideas—ideas that were killed at their birth. Even among the most intelligent of men, there is a latent tendency to think that a thing is well known when it is named. And with this tendency goes another, the tendency to regard two things as being wholly different when their names are different, although, as a matter of fact, the two things may be basically alike.

Before the processes of induction and deduction can be understood, a correct conception of their evolution must be had. Moreover, a complete explanation of these mental processes will not exist until their community with certain non-mental processes is perceived. This last statement will sound heretical to some and impossible to others. Even where its possibility is conceded, it may seem futile to show that there is any element of automatism about the processes of thinking. But it will be made clear later, I trust, that practical results will flow from this theory just as they have always flowed from every correct theory.

It should perhaps be needless to add that the acceptance of a theory of automatic thinking no more commits its advocate to atheism than does belief in the existence of a universe ruled by natural laws.

Explaining Mental Action.—The so-called explanations of the processes of observing, remembering and reasoning that are to be found in books on psychology and logic are, for the most part, mere naming of these phenomena in high sounding words, often accompanied by unproved hypotheses.

Mental processes can never be philosophically explained until kinship is established between them and processes that are not mental. Starting with this conception of the problem of explaining mental action, let us progress as far as we may in the present state of scientific knowledge.

Explanation of Sense-Records.—Each of the sense organs is actuated by energy in some one of its forms. Taste and smell are chemically actuated. Touch and hearing are mechanically actuated. Sight is etherially actuated. In every case some form of motion actuates a sense-organ, resulting in chemical changes in a nerve, thus "transmitting" motion to a nerve-center where a sense-record is "inscribed" in the nerve-stuff.

If we expect to explain either a sense-organ or a sense-record we must do so by finding its analogue or likeness in the natural world or in the world of artifice or both. I have selected the world of artifice—the man-created world—in which to find the first crude explanations of sensation and of thought itself.

Prior to about 1840 there was no artificial device except the camera obscura, suggestive of the action of any of the sense organs. When, in 1802, Wedgwood published "An Account of a Method of Copying Paintings on Glass," the first step was taken toward photographing objects. But it was reserved for Niepce, Daguerre and Talbot 40 years later to produce photographs by processes analogous to those now used. Thereafter, in the combination of the lens of the camera and the sensitized plate there was had a device remarkably suggestive of the eye and its retina.

In 1877 Edison patented the phonograph, and thus made known another process of recording the effects of an invisible wave force that is "perceived" by one of the senses. The subsequent perfecting of a moving picture device by the same inventor may be mentioned as another step toward giving us a mechanical idea, as we may call it, a reproduction of things once seen.

Prior to these inventions it was impossible, it seems to me, to attempt even a crude explanation of the action of the senses and the sense-records that we term ideas or thoughts. But with these invented devices, coupled with our present knowledge of physics and chemistry, we may take a first step toward explaining certain mental actions.

The eye is a living camera whose lens throws a picture on a chemically sensitized plate called the retina. The rays of light change the chemical composition of the retina, but the change is not permanent. There is incessant renewal of the chemical composition of the retina. That the renewal is not instantaneous, however, is proved by the persistence of vision—the brief lingering of the photograph on the retina after the photographed object is removed.

The chemical change in the retina results in progressive chemical changes in the optic nerves, and these changes cause an energy-wave along the nerve to the brain. There the nerve-wave registers an impression on the brain, forming what may be termed a sight-record. Similarly the other senses serve to produce their respective kinds of sense-records.

Progressive Formation of Sense-Records.—Every class of sense-record has been slowly produced. In this slow process of recording there is analogy to the exposure of a sensitized camera plate in a room. One short exposure either produces no discernible picture of objects or else a very dim picture of the brightest objects only. But let a succession of short exposures be made, and the negative will progressively record a more and more distinct picture of the objects. A sight-record in the brain is made progressively clearer in the same manner. This may be proved in many ways.

When a Caucasian first goes among Chinese "they all look alike," due to the fact that the Caucasian has not repeatedly seen Chinese.

To illustrate strikingly how a sense-record becomes clarified by repeated recordings, let an expert in any art be contrasted with a tyro. The skilled tea-taster can distinguish blends that are entirely beyond the perception of the ordinary person. Similarly the expert buyer of tobacco detects minute differences in flavor, whereas the non-smoking man can barely classify tobacco as "mild" and "strong." To the skilled musician there are harmonies and overtones unheard by the ordinary listener. The artist sees delicate variations in shades and can match colors with a precision wholly beyond the unexperienced user of colors.

There is a deeper truth than is commonly realized in the old saying: A man sees with his eyes only what is already in his mind.

Imagine the making of a phonographic record on wax, whereon a needle, impelled by a gently moving diaphragm cuts a slight groove. Let the needle pass again over the same groove, vibrating exactly as it vibrated before and at precisely the same time. The groove will be cut a trifle deeper in the wax. Each repetition will give a deeper cutting. Similarly, although of course chemically instead of mechanically, the sense-records are more "deeply" inscribed in the brain by repeated recordings.

In considering the progressive deepening and clarifying of sense-records, we must remember that we inherit certain sense-records that are already well developed; but that in our progenitors, far back, all classes of sense-records were at first vague.

If a number of different individual things are "exposed" before the "camera" of a given brain, and if those different individual things have, say, two elements in common, the mental "picture" will be stronger as to those two elements than as to any other elements. It is in this way that a mental "picture" of a class of things is formed prior to the making of a mental "picture" of any given individual of that class. In other words, the process of automatic generalization precedes the process of recognizing individuals.

Automatic Induction.—Automatic induction is the process of forming a sense-record of a relationship between two or more classes of things as a result of unintentional observation. The composite mental "picture" thus formed is an automatic generalization in which only certain common elements occur. Thus, an African deer forms a composite "picture" of lions, in which several of the "marks" of the class lion appear—its shape, size, tawny color, loud roar, peculiar odor, etc. Upon witnessing the attack of a lion upon one of its mates, the existing mental "picture" of the class lion is enlarged, the new "mark" of dangerous ferocity being added.

Whatever is automatically remembered about a given class of things is part of a mental "picture" of that class and is an automatic generalization.

Ordinarily it requires many repeated perceptions of a given kind of thing to make a persisting (=rememberable) sense-record; but a single, vivid perception of a new attribute of an old kind of thing may serve to make a persisting impression in the brain. The lower animals form no new mental pictures save after many repetitions, and the lower they are the more numerous must the repetitions be. Conversely, the higher the intelligence, the fewer the repetitions needed to produce a lasting sense-record.

From this it can be inferred that the thinking of animals low in the scale of intelligence relates only to classes of things and never to individual things except as members of a class. In other words, they reason only in generalities. As we ascend the scale of animal intelligence, we see many evidences of the truth of this deduction. We note, for example, that birds are slow to learn to distinguish one man from another, and that they readily mistake a "scare crow" for a man; whereas dogs quickly learn to recognize individual men.

If this conception of automatic induction is correct, it should serve to change existing ideas as to the process of volitional induction, and coincidently to make it apparent that systematic observation should be taught as a part of logic. Moreover, this explanation of automatic induction removes the ancient mystery of the supposed mental leap from an observation of a few known objects of a class to an inference that all objects (past, present and future) of that class must have the same class marks that the few have. The fact is that the process of induction is primarily automatic and always occurs during the formation of a composite sense-record of anything. The brain automatically starts with a generalization for its first records are of classes of objects. Then subsequent observations may narrow the generalization in some respects while broadening it in other respects. But until it is narrowed or broadened by observation, the mind invariably, because automatically, anticipates complete concordance of any member of a class with all the other members of the class.

The mind when acting automatically never begins with "This and that lion is tawny" and thence to the generalization that "Every lion is tawny," but starts at once with the generalization that "Every lion is tawny" if all lions thus far seen have been tawny. The very nature of a sense-record makes it automatically reproductive of itself, so that to say "All lions that I have seen are tawny" is to say "Every lion is tawny" until a lion appears that is some other color. If a black lion were to appear and be recorded in the composite sense-record of lions, the tawny color would cease to be one of the class marks of lions, but the other class marks would persist—the large head, the peculiar odor, the roar, etc. Not one of the class marks can be obliterated in any other way from a sense-record of a class than by sensing an object having all the previously recorded class marks save that one.

I conceive that the minds of animals invariably generalize every particular instance when first observed and that this is the inevitable consequence of the physical-chemical nature of the nerve centers that record perceptions.

The minds of men act in a similar manner when they act automatically, as they commonly do. The more uneducated the man the more is he given to generalizing from single experiences, because of the inherited tendency to think automatically and therefore to reason in general terms.

Activating a Sense-Record.—A sense-record, like a phonograph record, remains inactive until some energy stirs it into activity and causes it to "reproduce" or "play." The commonest cause of such "reproduction" is the presentation to the sense-organs of an energy-group identical with or similar to the original energy-group that made the sense-record. Thus the presentation of a rose to the eye causes the previously formed sense-record of a rose to "reproduce" itself and play synchronously or in harmony with the rose that is presented.

How such an automatic synchronization of a sense-record with an object is effected may be at least crudely explained thus: A tuning fork that is sounding a note will automatically cause a similar tuning fork near by to sound the same note. Similarly the vibration of corpuscles in the sight nerve that enters the brain may cause certain corpuscles of the brain to vibrate in unison, and these brain corpuscles thus made active are those "attuned" to such harmony. In other words, a given sense-record of a given sound replays in synchronism with the sort of nerve action that originally produced that sense-record.

In like manner every kind of sense-record is activated by the presentation of the kind of "object" (or energy-group) that originally made the sense-record.

This crude and simple explanation is obviously only a first step toward a more complete explanation of the process of observing or perceiving things.

So-called novel objects are novel only in the new combination of old elements. Thus, an animal that is of a species or genus new to the observer is like other animals in many respects and is also like inorganic objects in some respects. Its hair, for example, may be of unusual length and peculiar in color, but it is hair and it is colored. Although the combination is novel the elements are not, and they activate old sense-records.

The act of perceiving an object through any of the senses consists in synchronizing or harmonizing the object with a sense-record as above explained. Yet the very act of perceiving serves to develop a sense-record into more perfect synchronism or harmony with the object. There is thus a veritable cause-effect ring, which is a paradox that seems inexplicable to one who lacks philosophic understanding of the endless chain of motions that constitutes all phenomena. A clearing up of the paradox will be relatively easy after study of the subject of cause and effect.

Persistence of Active Sense-Records.—All active sense-records exhibit a tendency to persist, that is, to continue a forward movemnt of reproducing the record. This phenomenon is akin to the continued forward playing of a phonographic record, once the record has been set in motion. Let a child be taught a few verses until the sense-record has become deeply carved by repetition. Then name two or three words of any verse in sequence and the child will readily and speedily finish the verse; but will fail utterly in an attempt to recite backward from the given words. In general, the automatic "playing" of any sense-record proceeds in a forward direction; that is, in the same direction in which the record was originally produced.

It is this phenomenon of automatic forward "playing" of a sense-record, once it has been made active, that explains what may be called automatic deduction, or what psychologists call "association of ideas."

As will be more fully explained later, if there is a complex sense-record deeply "graven" in the mind of an animal or man, and if there is perceived an object that synchronizes or is in harmony with part of this complex sense-record, the rest of the complex sense-record automatically starts to reproduce. Thus, if a deer smells the odor of a lion, the rest of the complex sense-record relating to lions begins to reproduce, and the deer takes to flight to escape death, death of deer being part of the deer's complex sense-record relating to lions. It is properly said that the deer deduces the presence of the lion and the resulting danger of death from the perception of the lion's odor.

Automatic Deduction.—Automatic deduction is the process of automatically reproducing a remaining part of a sense-record of a class of thing as a result of perceiving one or more of the "marks" of that class.

When an object acts upon the senses it causes the sense-record of a like object to reproduce itself in harmony with the perceived object, and this activating of a part of the sense-record causes other adjacent parts to become active also. Hence automatic deduction is merely a sequel to a recognition.

To illustrate, take a deer's automatic generalization respecting lions: Every large, tawny, roaring beast of peculiarly pungent odor kills deer.

Now let the deer sense any part of this complex, as, for example, the odor, and it automatically deduces the rest; or, as some would say, arrives at it by instinct.

(1) Every lion has marks a, b, c, d, and kills deer.
(2) This thing has mark d (peculiar odor).
(3) Therefore this thing is a lion and kills deer.

It is well to note that this form of deduction differs materially from the syllogistic form given in books on logic. The syllogistic form would be:

(1) Every lion kills deer.
(2) This thing is a lion.
(3) Therefore this thing kills deer.

Since the syllogism will be discussed in a later article, we need only note, in passing, that it is a highly artificial process much resembling the combination of two equations to produce a third, and that it has consequently served to obscure the nature of deductive reasoning in general. Substituting algebraic symbols for words we can write the above given syllogism thus:

(1) $L > k$
(2) $t > L$
(3) $\therefore t > k$

$L =$ the class lion, $k =$ the attribute of killing deer, $t =$ this thing.

Based upon this artificial process, logicians have been led to say that all deduction consists in combining two premises to produce a conclusion; and they have held up mathematical deduction as the ideal form of deduction. But, as above shown, automatic deduction is quite a different process from the process of combining two propositions or two equations. Moreover it is a far more rapid process, so rapid, indeed, as to have obscured the fact that it is justly entitled to be called a process of reasoning.

When a prize fighter sees by a peculiar expression in his opponent's face that a blow is about to be delivered, he instantly prepares to receive or to avoid it. If he had to take time to form a syllogism leading to his conclusion he would be knocked out before he could formulate the first premise.

A consideration of such facts makes it evident that syllogistic deduction is only a class, and by no means the commonest class, of deductive thinking. Yet books on logic have hitherto discussed no other form of deduction than the syllogistic form which was fathered by Aristotle twenty-two centuries ago.

Factor of Safety in Concrete Floors

There has been a persistent impression, due no doubt to the very apparent solidity and stiffness of the concrete building, that the floors are being designed more heavily than is required for the work they are called upon to do. This idea has little basis in fact, according to R. R. Parker of the Aberthaw Construction Co., Boston. Mr. Parker states that the present practice of using a factor of safety of four in designing not only the floor slabs but the other elements of the building gives a result which, while it is amply secure for all legitimate loads, is none too heavy for the usual requirements.

Ordinarily a manufacturing building is figured for a live load of somewhere between 150 and 300 lb. per square foot. It is unusual for a factory load to exceed the design by any serious margin. In a storage warehouse, however, where the building may be designed for a dead load of 300 lb. per square foot, it is not unusual to find goods stacked clear to the ceiling, and an actual load on the floor frequently double that which was anticipated. In such cases it must be remembered that the design provides so many pounds per square foot for the entire floor area inside the outer walls. Necessity for leaving aisles and other means of access to the goods reduces the apparent floor load to a degree much closer to that for which provision was made in the design.

Occasionally even this condition is not met. In a storage building for a large munitions company, built by the Aberthaw Construction Co. some time ago, the great weight of the goods to be stored was taken into account, and the building designed for a load of 800 lb. per square foot. Ammunition was produced so much more rapidly than it could be shipped that much of it had to be stored. As the enormous quantity was all of one kind, and access to different parts of the storage was not necessary, the boxes were stacked clear to the ceiling and over the entire area of the floor from window to window. No aisles were left or any other vacant spaces, and the building was actually called upon to bear a static load of about 1,500 lb. per square foot, or practically double that for which it was designed. Even with this tremendous burden the building showed no signs of distress.

In another case, where the actual load applied was approximately three times that designed, incipient cracks have appeared on the lower side of the floor panels. There is no fear, however, that the building will fail to stand up, even under this great abuse. The cracks indicate simply a little more deflection in the panel than was expected; and it is believed that the steel members upon which alone reliance is placed for tensile strength, are not in any way seriously affected.

The whole question of bulk as applied in a floor slab is tied up intimately with the question of vibration in the building. Storage buildings without manufacturing processes going on are not ordinarily subjected to much vibration, unless it may be from the occasional disturbance of a passing train. In manufacturing buildings, however, the problem sometimes assumes serious proportions, particularly where heavy reciprocating machinery is used.

Bulletin on Analysis of Statically Indeterminate Structures.—We are advised that copies of the new bulletin of the engineering experiment station of the University of Illinois on the analysis of statically indeterminate structures by the slope deflection method can, for the present, be obtained free. Later as the number of available copies is reduced a charge of $1 will be made. In the review of this bulletin in our Dec. 24 issue, the name of one of the joint authors was erroneously given as F. E. Rideout. This should have been F. E. Richart.

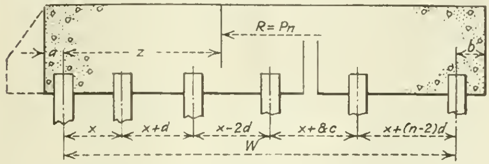
Foundation Pile Spacing for Eccentric Loads

By J. W. PEARL.

In designing a pile foundation for any load it is generally desirable to arrange the piles so that each one will be equally loaded. When the load is eccentric to the area to be used and a number of piles or rows of piles are required the "cut and try" method is both tedious and uncertain.

Having determined the position and amount of the resultant of the loads to be supported and the desired load per pile, the number of piles will be determined and they can be arranged in rows appproximately at right angles to each other with the number of piles in each row approximately proportional to the dimensions of the area to be covered.

Let the figure below represent a section at either one of these rows and assume values of a, and b, suitable to cover or enclose, as desired, the outer row of piles, and—



Make $x = (6z - 2W)/(n - 1)$ ....(1)

and $d = (6W - 12z)/(n - 1)(n - 2)$ ....(2)

In the figure and the demonstration following:

Let

R = the resultant load in position and amount.
P = the equal load on each pile.
W = distance center to center of front and rear piles.
z = distance derived from R and W.
n = number of piles in row considered.
x = distance from first to second pile.
d = increments in spacing for succeeding piles.

Demonstration.—The variation in spacing is assumed to start from x and increase in arithmetical progression.

The summation of spaces $= (n - 1)x + [(n - 1)(n - 2)/2]d = W$ ....(3)

Moments will be taken about the center of the left hand pile and the summation of lower areas will be:

$n(n - 1)x/2 + n(n - 1)(n - 2)d/6$ ....(4)

The moment $= P.n(n - 1)x/2 + P.n(n - 1)(n - 2)d/6 = Rz = P.nz$ ....(5)

This gives $(n - 1)(n - 2)d = [z - (n - 1)x/2]6$.

The equation for W gives $(n - 1)(n - 2)d = [W - (n - 1)x]2$.

Hence $6z - 3(n - 1)x = 2W - 2(n - 1)x$,

Or, $x = (6z - 2W)/(n - 1)$ as above.....................(1)

The value of d is derived by substituting this value of x in the equation (3).

Discussion.—Considering equation (1) it will be evident that the value of x diminishes as z diminishes and as either W or n increases. Cases will arise in which the values of x will be so small that the piles could not be driven.

The remedies in such cases are:

1. Diminish W by increasing b.
2. Increase z by extending the wall at c with an offset as indicated by dotted line and placing the front piles farther to the left.
3. The number of piles per row may be diminished by using more rows.
4. The number of piles may be diminished by using piles of higher bearing value.

It is so easy to try all of these revisions by simple substitution in equation (1), that there can be no excuse for substituting "guessing" for correct design by computation.

Actual guess work is frequently disguised under the more diplomatic terms, "practical experience," "good judgment," "common horse-sense" and other non-quantitative expressions.

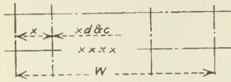
Extreme Conditions.—In some cases z may be equal to or less than W/3; then (x) in equation (1) becomes zero or negative and the equation for x and d will not apply.

In this case if the distance to adjacent rows of piles makes it feasible to drive an intermediate pile in the front row, the value of n in equations (3), (4) and (5) may be reduced by unity and equation (5) becomes:

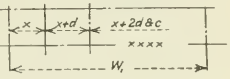
$Pn(n - 1)x/2 + Pn(n - 1)(n - 2)d/6 = Rz = P(n + 1)z$... (6)

and new values for x and d may be determined for a general case as before, or the particular values of n for the case considered may be substituted in (3), (4) and (6) and the values of x and d be determined for this particular case.

In extreme cases, it may be desirable to use more than one pile in an intermediate row or a group of piles, as shown in plan below:



Case (2).



Case (3).

For case (2), two piles in the intermediate row, equation (5) becomes:

$Px + Pn(n - 1)x/2 + Pn(n - 1)(n - 2)d/6 = Rz = P(n + 2)Z$ .....(7)

For case (3), three piles in the intermediate row, equation (5) becomes:

$P(3x + d) + Pn(n - 1)x/2 + Pn(n - 1)(n - 2)d/6 = Rz = P(n + 3)z$ ....(8)

For a case of four piles in the intermediate row equation (5) becomes:

$P(6x + 4d) + Pn(n - 1)x/2 + Pn(n - 1)(n - 2)d/6 = Rz = P(n + 4)$ ....(9)

In similar manner, the equation may be written for any possible group of piles.

In designing the spacing along the other axis of the foundation, which should be approximately at right angles to the lines heretofore located, the rows or groups may be treated as units and the spacing of rows or groups may then be determined by equations (1) and (2).

The load upon a foundation is generally variable and there will be many values of z and R—with two limiting values. But little work is involved in designing for both limits and selecting an average or the probable value for the final arrangement.

The values determined for x and d will generally involve fractional measurements, but no appreciable error will result from using balanced adjustment and dimensions that are easily measured.

Some References to Publications on Marine Borers

Information on the methods used in combating marine borers, which attack wooden structures in sea water, may be gained from the following publications:

Preservation of Piling Against Marine Wood Borers.—U. S. Forest Service Circular No. 128. 1908.

Efficiency of Various Parts of Coal Tar Creosote Against Marine Borers.—C. H. Teesdale, in Engineering Record, Sept. 12, 1914.

Preservation of Structural Timber.—H. F. Weiss, McGraw-Hill Book Co. 1916.

The Comparative Toxicity of Coal Tar Creosote and Creosote Distillates and of Individual Constituents for the Marine Wood Borer, Xylotrya.—L. F. Shackell, in Proceedings of American Wood Preservers' Association, 1915, pages 233-247.

Destruction of Timber by Marine Borers.—E. S. Christian and others, published in Proceedings of American Wood Preservers' Association, 1915, pages 296-316.

Marine Borers From the Wood Preservers' Standpoint.—L. F. Shackell, Proceedings of American Wood Preservers' Association, 1916, pages 124-131.

Field Tests Made on Oil Treatment of Wood Against Marine Borers.—C. H. Teesdale and L. F. Shackell, Engineering News-Record, Nov. 1, 1917, and Railway Age Gazette, Nov. 2, 1917.

Surface Tensions of Wood Preserving Oils as Factors in Protection Against Marine Borers.—Proceedings of American Wood Preservers' Association, 1919, pages 113-123.

Transportation Engineering Added to N. Y. U. Course.—A course in motor transportation engineering is to be added to the curriculum of New York University, to begin in February, according to an announcement made by Dean Charles H. Snow, of the School of Applied Science. The new study is to be given by F. Van Z. Lane, chief transportation engineer of the Packard Motor Car Co., Detroit. It will form a part of the new course in industrial engineering and will be open to students in mechanical and civil engineering, particularly those specializing in subjects relating to highway engineering.

Factors a Contractor Should Consider in Estimating

The average contractor forgets a great many things which should be included in making up his estimate. It is true that many of these items are small and it might seem that they are insignificant, but when several are taken together the cost increases rapidly. In an interesting article in the January Contractor's Atlas, Mr. D. S. Colburn, formerly with the Fahry Construction Co., Green Bay, Wis., points out certain of these matters that are commonly overlooked in estimating. The article in abstract follows:

It is probable that on an average about 6 per cent of the cost of the job is not taken into consideration when the estimate is made. The following table illustrates this point:

SCHOOL BUILDING 130′ 0″X200′ 0″—3 STORIES, NO BASEMENT.

167	yds. rock excavation at $2	$ 934.00
880	yds. earth at 30 ct	240.00
9,900	cu. ft. concrete footing at 22 ct	2,178.00
11,880	cu. ft. concrete walls at 25 ct	2,970.00
13,524	sq. ft. reinforced concrete floor in corridors and toilets at 35 ct	4,733.40
13,524	sq. ft. terrazo floors at 25 ct	3,381.00
1,980	lineal ft. terrazzo base at 35 ct	693.00
7,914	sq. ft. plain cement floors at 10 ct	791.40
182,160	face brick at $35	6,375.60
1,339,240	common brick at $18	24,106.32
32,000	sq. ft. partition tile at 12 ct	3,840.00
3.960	cu. ft. cut stone trimmings at $1.75	6,930.00
58,000	enameled brick at $50	2,900.00
16,059	yd. lath and plaster at 40 ct	6,423.60
50	lineal feet tile flue lining at 75 ct	37.50
6,000	lineal ft. corner beads at 6 ct	360.00
1,800	yd. metal lath at 45 ct	810.00
4,725	sq. ft. slate blackboards at 28 ct	1,323.00
2,160	sq. ft. cork tackboard at 28 ct	604.80
27,000	lineal ft. grounds at 1½ ct	405.00
96	squares steel ceilings at $7	672.00
	Moving picture booth with vent	......
	Balcony in gymnasium	1.896.00
66,000	ft. maple floor at $65	4,290.00
500,000	ft. lumber at $45	22,500.00
260	squares roofing at $7.50	1,950.00
500	squares floor deadening at $2	1,000.00
47	tons structural steel at $115	5,405.00
3	Iron stairs (sub-bid)	2,600.00
	Hardware trim	1,700.00
	Sheet metal (sub-bid)	890.00
	Millwork, sash, doors, trim, etc. (sub-bid)	8,197.00
	Labor on millwork	3,278.80
	Painting (sub-bid)	1,890.00
	Usual estimate	$126,585.42
	10 per cent profit	12,658.54
	Usual bid	$139,243.96

FORGOTTEN ITEMS.

Bond, 1 per cent	$ 1,490.00
Fire insurance, ½ per cent of $100,000	500.00
Liability insurance, 5 per cent of labor, $48,000	2,400.00
Telephone	160.00
Traveling expenses, board, etc	650.00
Temporary office, locker, sheds, etc	548.00
Water for building uses, temporary piping, hoists, etc	182.00
Lights, fences, barricades	80.00
Watchman, 6 months at $70	420.00
Timekeeper	350.00
Engineer, laying out, batter boards, etc	30.00
Protection of erected work	100.00
Temporary heating 6 months will burn 220 tons coal at $7	1,540.00
Cleaning out building	100.00
Carting debris	25.00
Cutting and jobbing for other trades	430.00
	$ 9,005.00

BID SHOULD BE.

Usual estimate	$126,585.42
Plus items overlooked	9,005.00
Correct estimate	$135,590.42
Plus 10 per cent profit	13,559.04
Correct bid	$149,149.46

It frequently happens that the general specifications are glanced over in a superficial manner, the contractor immediately taking the plans and specific specifications and estimating all materials and workmanship. When the materials and labor have been figured from these, 99 per cent of the contractors think that nothing remains to be done except add the usual 10 per cent for profit. The trouble is that the general specifications are not carefully enough observed and studied.

As an example of this, there was a large contracting concern recently figuring on a drainage job of considerable magnitude. A close study of the specifications revealed the fact that the contractor was responsible in many ways which ordinarily would not involve any responsibility on his part. For instance, he had to guarantee the designer's work and if this job was done according to the plans and specifications, and it didn't work, then the contractor would receive no payment for the job. This happens in many cases.

In another instance, the specifications made the contractor responsible for the work under the specifications and plans as stated. In other words, the plans were prepared by the architect but the contractor was held responsible. One part of the specifications referred to a basement floor and stated that the contractor should guarantee the basement floor slab to stand a certain head of water. The slab has failed and it is a question now who is responsible.

There are certain matters that are commonly overlooked in estimating and these may be chiefly summarized as follows:

(1) Surety Bond—A surety bond guarantees the faithful performance of the contract and payment of all bills in connection therewith. One per cent is the amount commonly charged for this bond no matter how big or how small the job. Many contractors pass this up and think that they can take care of it out of their 10 per cent profit. It may seem that this is rather the exception than the rule and that very few contractors would neglect to take care of this feature. It is surprising how great a number and how many of all classes of contractors neglect to take this factor into consideration.

(2) Liability Insurance — Liability insurance usually amounts to 5 per cent-8 per cent of the total labor cost. This can be figured at that amount and should always be taken into consideration.

(3) Temporary Heating—Another item scarcely, if ever, figured in is temporary heating. Heating is required not only in winter work, but also in early spring or fall construction. While the job may start in the summer, it should be borne in mind that it may possibly run into the winter and therefore, the problem and cost of providing temporary heating should be taken into consideration.

(4) Temporary Enclosures—These are frequently needed, especially in the case of winter work. They are often required to enclose a part of a building so as to afford public protection. Frequently in the case of a building located in the city, roofing is required above the sidewalks. Material sheds are always needed. These items are small but, of course, count up.

(5) Water for Building Use, Temporary Piping and Hoists—It should be taken into consideration that water will be required for various operations connected with the building, for instance, the mixing of concrete, in keeping the concrete wet, and in cleaning. Elevators or hoists are required for elevating the materials to the proper place. This is an item that is many times neglected. The contractor figures that it costs so much to lay so many bricks, but the means of getting them in place is not considered.

(6) Fire Insurance—During the process of construction the building is under joint ownership by the contractor and the individual or company for whom the building is being constructed and, in the event of loss of the building by fire, the loss is prorata. The fact remains that the contractor must pay the premiums on the job until finished.

(7) Engineer, Time-Keeper, Watchman—A service engineer is required in connection with the layout and other details. This expense is, however, very slight. But the expense of the timekeeper and watchmen, in case of a large job, amounts to a very appreciable figure.

(8) Telephone Service—Sometimes telephone service is not required, while there are times when it is a great necessity and this item of expense should also be considered.

(9) Traveling Expenses—This item covers the cost of transporting the foremen or other laborers sent out of town away from their homes. The contractor must as a rule pay all of the railroad fares and board for these men as well as his own expenses.

(10) Cutting and Jobbing—Cutting and jobbing for other trades is a large item since the general contractor is usually required to cut all openings for electricians, plumbers and steamfitters and to patch these up after these workmen have finished.

(11) Guarantee—Often the architects require that the contractor guarantee the material and workmanship for two years or maybe more. This is an item of considerable importance and is never taken care of under the general overhead expense. The United States Government figures 1½ per cent depreciation per year on buildings, so it is an easy matter to gain an idea of how much this item alone amounts to.

Moments in Columns and Girders of Building Frames Due to Vertical Loads

By W. M. WILSON and F. E. RICHART.

If a floor girder of a building carries a load it is common knowledge that the girder is subjected to a bending moment. Further, if the ends of the girder are rigidly connected to columns, the fact is recognized by most designers that the load on the girder produces a bending moment in the adjacent columns. It is not, however, so universally recognized that the load on one girder may cause a moment in a girder or column, one or more panels away. Further, the total moment in a girder due to the loads in a number of panels may be much greater than the moment due to the single load carried by the girder in question. Likewise the moment in a column, due to the loads on a number of girders may be much greater than the moment in the column due to the load on a single adjacent girder.

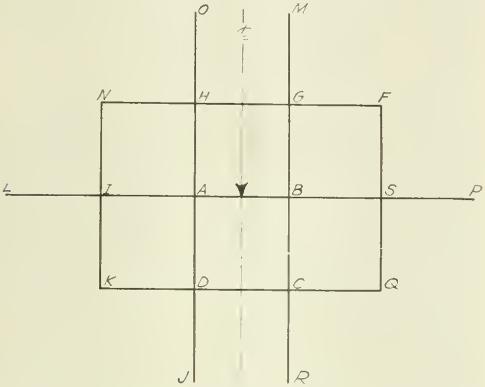


Fig. 1.

Consider in detail the cumulative effect of loads on a number of panels of a building. Fig. 1 represents a frame of a building for which all column and girder connections are rigid. A load on the girder AB produces a moment in the girder at A. A load on the girder 1A causes the connection A to rotate thus also producing a moment in the girder AB at A. Likewise a load on every girder of the frame produces a moment at A. Although loads on all girders produce moments at A the moments due to loads on some girders are of opposite sign, or counteract the moments due to loads on the other girders. If all of the loads which produce moments of the same sign are applied, and no others, the moment at A in AB will be a maximum.

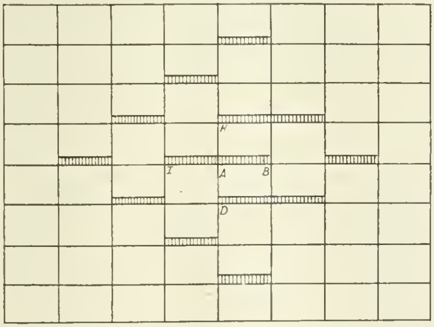


Fig. 2—Loading for Maximum Moment in Girder AB.

Figure 2 shows the panels which, when loaded, produce a maximum bending moment in the girder at the point A.

The effect of the load on one girder upon the moment in another girder depends upon a number of very complex factors, and the exact determination of the moments is impossible. However, the writers have made an extensive study* of the problem and recommend certain empirical values for the maximum bending moments in columns and girders.

Consider that all girder spans are equal and that the loads on all girders are equal and that the loads are symmetrical about the centers of the girders. Let M represent the moment at the end of a girder with fixed ends having the same length and carrying the same loads as the girders of the building. Let K represent the ratio of the moment of inertia to the length of a member, that is $K = I/l$. If the K's of all members are equal the moment in the girder at point A of Figure 2 is 1.2 M. Loads on girders further removed from A than the loads shown in Figure 2 produce a moment at A, but the values of these moments are very small. Although it requires loads on fourteen specially selected girders to produce a moment in a girder equal to 1.2 M, a moment of 1.13 M is produced by loading two adjacent girders AB and AI. This latter load distribution is one that is very likely to occur many times during the life of a building and should be considered by the designer.

If the stiffness of the columns is increased the effect of a load on one girder upon the moment in an adjacent girder is decreased.

Considering the K's of all columns to be equal and the K's of all girders to be equal, the moment for which a girder should be designed is given in Fig. 3. The lower curve represents the moment due to loads on two adjacent girders only, whereas the upper curve represents the moment resulting from loads shown in Fig. 2. Inasmuch as the load on no other single girder will produce a moment greater than 3½ per cent of the moment due to loads on the two adjacent girders, and inasmuch as the load distribution shown in Fig. 2 is not likely to occur, the lower curve should be used. This curve represents moments in a girder of a frame for which the K's of all girders are equal and for which the K's of all columns are equal. If the K's of all columns are not equal, use as the K of the columns the average values of the K's for the column just above and just below the girder at the end of the girder where the moment is to be determined, that is the average of K of AH and K of AD. If the K's of the girders are not equal use as the K of the girders the average values of the K's for the two adjacent girders loaded, that is the average of K for AB and K of AI.

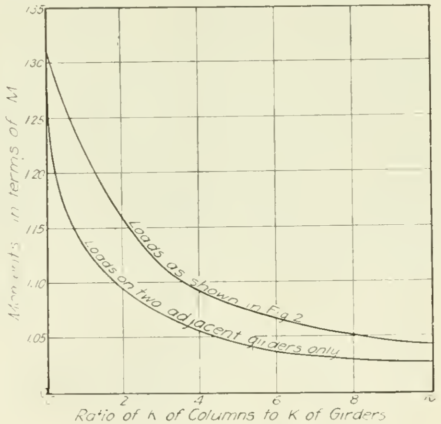


Fig. 3—Moments in Girders.

As loads on a number of girders produce moments of the same sign on a specific girder so loads on a number of girders produce moments of the same sign on a specific column. Fig. 4 shows the girders which, when loaded, produce a maximum moment in the column at A. Letting M represent the same moments as in the case of the girders and considering the case in which the K's of all members are equal, the moment at A for the load distribution shown in Fig. 4 is .48 M. Although it requires loads on twelve specially selected girders to produce a moment in a column equal to .48 M, a moment of .38 M is produced by the loads on two girders, one just above and the other just below A, that is on AE and BF. This latter load distribution is one that is very likely to occur many times during the life of a building and should be considered by the designer.

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*Bulletin No. 108, Engineering Experiment Station, University of Illinois, by W. M. Wilson, F. E. Richart and Camillo Weiss.

If the stiffness of the columns is increased the effect of a load on a girder upon the moment in a column is increased.

Considering the K's of all columns to be equal and the K's of all girders to be equal, the moment for which a column should be designed is given in Fig. 5. As with Fig. 3, the lower curve of Fig. 5 should be used for the purposes of design.

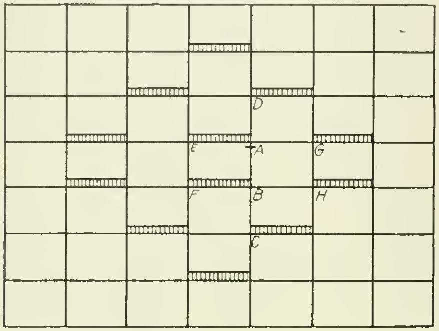

Fig. 4—Loading for Maximuh Moment in Column AB.

The curves of Fig. 5 are for a building for which the K's of all stories of the column are equal. If the K's of all column stories are equal the moment at the top of the column equals the moment at the bottom of the column under the conditions assumed for this problem. If, however, the K of the column BC is greater than the K of the column AD the moment in AB due to the loads on AE and BF will be greater at A than at B. If, on the other hand, the K of column BC is less (due to a large story height) than the K of AD, the moment is greater at B than at A.

To determine the moment in AB, if the K's of all columns are not equal, use as the K of the columns the average of K_{AB} (or K for AB) and K_{AD}. (Use K_{BC} instead of K_{AD} if K_{BC} is less than K_{AD}.) Multiply the coefficient of M given by the curve of Fig. 5 by the factor $\frac{5K_{AB} + K_{AD}}{3K_{AB} + 3K_{AD}}$

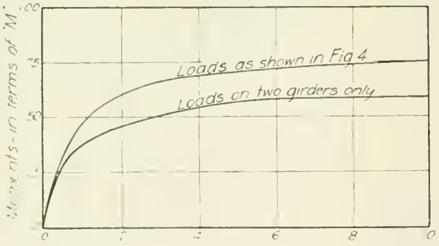

Fig. 5—Moments in Columns.

If K_{BC} is less than K_{AD} substitute K_{BC} for K_{AD} in this factor.

If the K's of the girders are not equal use as the K of the girders the average of the K's of the girders AE, BF, AG, and BH.

The moments as outlined above, although not exact, are accurate enough for the purposes of design.

Values of M for a number of systems of loads are as follows:

Uniformly distributed load W on girder...... $M = Wl/12$
Single concentrated load P at center........ $M = Pl/8$
Two equal loads P, at distance a from ends.. $M = Pa(l - a)/l$
Two equal loads P, at third points.......... $M = 2Pl/9$
Three equal loads P, at quarter points...... $M = 5Pl/16$

Action of Seawater on Steel in Concrete Construction

In an interesting article by J. L. Harrison in the December issue of Concrete the action of sea water on the steel in reinforced concrete is thoroughly discussed. After the disintegration of the concrete itself the more conspicuous source of trouble with structures in or near sea water arises from the rusting of the reinforcing steel. Mr. Harrison's conclusions indicate that the deductions of Messrs. Wig and Ferguson as published in the Engineering News-Record, Sept. 20, 1917, are not well founded. Their statement was that "undoubtedly the real cause of the trouble is the accumulation of salts in the pores of the concrete above the water line by capilarity and evaporation, and the absorption, by the concrete, of air carrying very minute particles of sea water."

Extracts from Mr. Harrison's article follow.

The rusting of steel is evidenced by the appearance of unsightly cracks along reinforcing bars or (particularly in buildings) by the formation of "puffs" where the concrete has been broken away by the formation of dusting areas on an underlying bar. Repeated chemical examinations, both of the concrete from structures where rusting has progressed far enough to produce cracks, and of the scale from the rusted bars, serve to indicate that chlorine—undoubtedly common salt, NaCl, has been at the bottom of this trouble. It may, therefore, be accepted as reasonably well established that even when embedded in concrete, steel will rust rapidly if salt reaches it under conditions which also insure adequate supplies of moisture and oxygen.

This being admitted, there arises the question as to how the salt which is now causing trouble in concrete structures came to be there, and whether there is any way of preventing its inclusion in future work. To arrive at a determination of this matter, an examination of the condition found on various structures in the Philippine Islands is illuminating. Thus, take the Marilao bridge, a multiple span, reinforced concrete slab and girder bridge on the Manila North Road, as an example. The girders under the span on the Manila end of this structure are rusting badly. The balance of the structure appears to be in good condition except for a few cracks in the last span on the Marilao end of the structure.

The cracks in the failing span are confined to the girders, all of which are badly cracked, the cracks extending up the stirrups to about the level of the floor slab. All of the girders under this span, the inside ones as well as the outside ones, are badly cracked. The under side of the floor is sound. The top of the floor was not examined. The hand rail is in good condition.

The history of the structure is that the pouring was done at various seasons of the year at times when the water in the river was salty on account of its nearness to the ocean and again when it was fresh on account of floods. The correlation shown between the condition of water in the river when the various parts of the bridge were poured and the present condition of the steel in those parts serves to point clearly to the source from which the salt reached the affected spans—namely the river.

The other possible sources of salt, as salty water used in curing the concrete and the use of unwashed beach sand in the concrete, were both carefully investigated, and rejected on the ground that they had no general application.

The question of salt spray carried by the sea breezes as advanced by Messrs. Wig and Ferguson was also thoroughly investigated but the fact that the corrosion was in places only and that as likely on the side away from the direction of the sea breezes as on that side struck directly by them precluded any such cause. The fact that the parts of concrete badly affected contained 0.08 per cent chlorine is almost conclusive that salt water was used in the mixing.

On this and other structures examined it was found to be very hard to get reliable statements of the details of construction. The specifications in force in the Philippine Islands called for the use of fresh water in reinforced concrete. But this requirement was often violated. However, few would admit a violation unless the prospect of detection through a chemical analysis of the concrete in the finished structure seemed to be too great. Thus the results of the investigations in the Philippine Islands served to show the uselessness of trying to draw conclusions from the statements of interested parties.

The investigation of the Looc School building was typical of this condition of affairs. When the investigation of this structure showed that over 90 per cent of the short columns under the structure were cracking, the matter was brought to the attention of the man who was in charge of constructing this building, with an inquiry as to whether he had used sea water in mixing the concrete. His reply that he had not was modified to a statement that he had only used it to mix concrete for the short columns, where he was informed that some specimens of the concrete showed the mixing water must have contained at least 3 per cent of salt. The errors that Messrs. Wig and Ferguson fall into in assuming that capillary attraction and spray have been the important means of supplying the salt which has so greatly stimulated the rusting of steel in many reinforced structures in or near sea water would probably have been avoided had they not depended, as they say, on information secured "in conformity with a detailed questionnaire."

The Looc School is so close to the sea that the walls on the sea side are not infrequently wet with spray. As stated above, over 90 per cent of the short columns under the building are cracked, though most of them are never touched by spray, but not a crack was found above the short columns, not even on the side of the building exposed to the frequent wetting. The building stands on the sand far enough away from the sea and high enough above it so that capillary action as a factor may be dismissed. In this case the use of sea water has clearly been the cause of the trouble, and the fact that the walls which are wet with spray do not show any signs of cracking may be ascribed to the fact that such salt as is deposited is quickly removed by the tropical rains.

A school building in San Jose Antique has developed some cracking. This structure is on rather a pronounced hill, too high to make capillary action a possibility, but rather near the sea. However, the spray which reaches it never is enough to wet the surface. Some of the columns are cracked and the wall on the sheltered end shows some cracks. The exposed end was, so far as could be seen, free from cracks. Fresh water must have been used. However, beach sand and gravel were used, without washing. From what could be learned of the history of the construction of this building, and from chemical examinations it seemed that part of the aggregate lay for some time on the job and so was washed by the rains. In other parts of the building the sand and gravel were used as delivered from the beach. The trouble observed is undoubtedly to be charged to this use of unwashed beach aggregate. Here again is to be observed the significant fact that the side subjected to the direct action of the sea breeze was not affected.

The cities of Manila and Iloilo, P. I., offer a splendid opportunity to compare the results of concrete work under very similar conditions—only one marked difference being ascertainable. Both cities lie within the sweep of the monsoon as it comes off of the salt water. The buildings in both cities are on ground which is apt to be moist if not wet, but in neither city is the moisture at the depth of the footings noticeably saline. Manila has a good water supply system. Iloilo depends on wells, which run from fresh to slightly brackish, not brackish enough, however, to prevent their being used for drinking water.

In Manila most of the aggregate used comes from the Passig river, above the reach of salt water. In Iloilo the aggregate customarily used comes from the beach. In Manila, with a few exceptions, due to the use of other than city water, or to the use of beach aggregate from across the bay, etc., concrete work has been an unqualified success. The buildings are sound and show no sign of trouble. The writer had an opportunity a year or more ago to examine some of the steel taken from the floor of one of the oldest reinforced concrete buildings in the city. It was in splendid condition. On the other hand, in Iloilo, where beach sand has been used extensively, there is hardly a concrete structure which is free from rusting steel. In Iloilo it is customary to use unwashed beach aggregate and to deliver it only about as fast as it is used.

The difference that can be observed in the condition of the concrete structures in these two cities seems very significant of the damage which can be done by the careless use of aggregate carrying large percentages of salt. On the other hand, the location of these cities makes it certain that if the sea breeze really was the source of the trouble, the general behavior of the concrete structures should have been the same in both cities.

The last real source of danger to structures in ordinary exposure from the wetting of steel with salt water is either during shipment or while exposed on the job.

The cause of this condition of affairs in structures much too far inland to be affected even by salt spray, and built where no salt could have gotten into them through any other cause after their erection, was more or less a mystery until the writer had an opportunity to observe the trans-shipment of some steel at Apain, and the condition in which similarly treated steel reached its destination after a trip of a couple of months or more up the river.

The already forming scale showed all too clearly that the salt water which frequently got on to it during trans-shipment had, to put it very mildly, done the steel no good. That bars in this unfortunate condition had sometimes been used without proper cleaning—and after a salt water bath no ordinary amount of physical cleaning is sufficient—there can be no doubt. Moreover, in exposed locations, it often happens that salt spray will rust steel so rapidly after it is placed, but before concrete is poured around it, that by the time the upper ends of bars are reached scale will have begun to form. Such bars go on rusting after they are covered. It may, therefore, be advisable to avoid the use of reinforced concrete in such locations, at least until some adequate method of protecting the steel while it is exposed is devised.

The examples here given could be almost indefinitely extended from the list of hundreds of structures, docks and river walls, buildings, bridges and culverts which have been examined in the study of the question as to how salt gets into concrete structures. However, it must suffice to say, in closing this discussion, that of the hundreds of structures that the writer has examined which were within the known range of salt-laden breezes, but built under conditions which precluded any questioning of the fact that no salt could have gotten into them except from the air, not one has even shown the slightest indication of rusting steel.

It is hard to imagine a statement which could be farther from the truth. Some structures, in which salt had been included during construction, will probably give trouble, but if there is one thing which the writer's investigations have shown beyond any reasonable doubt, it is that the thousands of properly and carefully built concrete structures, even those near the sea, are perfectly safe, no matter how much salt spray may be blown on to them. The plain truth is that such spray is deported in very minute quantities and is promptly washed off by the rains. This is well, as otherwise none of the concrete work near the coast could be considered safe.

As all of these means of including salt in a concrete structure, except the wetting of the steel with salt spray, may be easily avoided, engineers should not hesitate to proceed with the use of reinforced concrete for ordinary marine and near-marine work. The difficulty of protecting steel from the salt spray in some exposures should have a limited effect on design. The more general use of unreinforced footings, where these footings actually stand in salty water, may be advisable, but there is no reason at all for supposing that reinforced concrete structures built of fresh water aggregate, the concrete mixed and cured with fresh water, and in which clean steel is used, are in any danger merely because the sea breezes blows over them.

This is not equivalent to a statement that there are no locations where the salt spray should be considered. A lighthouse on a rock, over which the spray constantly beats, may ultimately give trouble. A concrete dock floor within 2 or 3 ft. of high tide level may become saturated with salt water. But these are special conditions of very limited application. For the vast majority of structures, these factors may be completely ignored.

It is further desired to point out that while the safety of the reinforcing steel in all kinds of structures depends on the rigid exclusion of salt, anything which makes for increasing the density of the concrete will probably add to the ultimate life of the structure. In the present state of our knowledge of this subject, the question of ultimate life is merely a conjecture. But probably no one thing will do more toward guaranteeing the permanency of concrete construction, wherever located, than the use of proper materials free from salt, proper fresh water in a proper amount, and clean steel. If this is done there will be no trouble with the structure under any ordinary conditions of exposure.

"Fineness Modulus" and "Surface Area" Methods of Proportioning Concrete Mixtures

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I have been interested in reading the article in the Dec. 24, 1919 issue of Engineering and Contracting by Mr. R. B. Young, relating to the proposed "fineness modulus" and "surface area" theories for the proportioning of concrete mixtures. The writer is inclined to agree with Mr. Young's statement that the two theories are in agreement in final conclusion, but further believes that both theories are faulty, and their conclusions erroneous, because of the disregard of the basic and fundamental requirement that concretes must have the same consistency or flowability to be comparable.

In Lewis Institute Bulletin No. 1, describing the fineness modulus theory, Professor Abrams states that for a given plastic condition of the concrete and the same mix there is an intimate relation between the fineness modulus of the aggregate and the strength and other properties of the concrete. It is further stated that the grading of the aggregate may vary over a wide range without producing any effect on the concrete strength so long as the water-cement ratio remains constant. Referring to the sieve analysis curves of the aggregates used, it is said that any other sieve analysis curve that will give the same total area below the curve corresponds to the same fineness modulus and will require the same quantity of water to produce a mix of the same plasticity, and gives concretes of the same strength so long as the aggregate is not too coarse for the quantity of the cement used. In other words, the fineness modulus theory concludes that for given concrete materials, the strength depends upon one factor only—the ratio of water to cement.

The surface area method of proportioning assumes as its basic principle that the physical properties are primarily dependent upon the relation of the volume of the cementing material to the surface area of the aggregate. It is further stated that the strength of the mortars are dependent upon the quantity of the cement in relation to the surface areas of the aggregates, and the consistency of the mix. Also, that strengths of mortars of uniform consistency, containing sand aggregates of varying granular combinations are directly proportional to the quantity of cement they contain in relation to the surface area of the aggregate. Mr. Edwards states that "normal" uniform consistency mortars of varying cement content and varying sand gradings were produced when the quantity of water used in the mix was made equal to that required to reduce the cement to a normal consistency paste, plus an amount equal to the surface area of the sand in square inches divided by 210, i. e.:

$$(1)\ \text{Water (cc)} = \text{Weight of cement (C)} \times \text{Percentage for neat normal consistency paste} + \frac{\text{Total surface area of sand (sq. in.)}}{210}$$

The similarity of the two theories in final conclusion can be seen in a study of the water formula:

Let C = Weight of cement in grams
p = percentage of water for normal consistency
A = Total surface area of the aggregate in square inches
N = A/C = square inches of surface area of aggregate per gram of cement. Arbitrarily selected before the test.
w = cubic centimeters of mixing water
c = volume of cement in c.c. = .67C.

As stated in (1), $w = pC + \frac{A}{210}$ ....(2)

from the above, $A = NC$ ....(3)

substituting (3) in (2), $w/C = p + \frac{N}{210}$, in which p and N are constants.

To express the weight of the cement in volume measure,

$w/.67C = p + \frac{N}{210}$ = constant, and which is the water-cement ratio proposed by Professor Abrams for equal strengths, or

$$w/c = K$$

Expressing this result in words, the surface area theory, after fixing a ratio of cement to surface area of the aggregate, arrives at the same final conclusion as does the method proposed by Professor Abrams, that strength depends only upon the ratio of mixing water to cement.

The fineness modulus theory states that the strength is dependent only upon the water-cement ratio, and the surface area theory arrives at the same final conclusion, after providing a relation between the quantity of cement and the surface area of the aggregate.

On any concrete work, it is necessary that the concrete have some minimum plasticity, consistency, flowability, in order that it may be placeable with a reasonable amount of work. For the same flowability, an aggregate containing much fine material will require a greater amount of mixing water than one which is coarse. Since it is generally agreed that any additional quantity of mixing water added to the same mix will result in lower strength, it is of the utmost importance that the laboratory accurately take into account this difference in water requirements, otherwise the relative water contents must be modified on the job to secure the necessary minimum workability, which in turn will result in concretes differing in strength from those produced in the laboratory. Lack of accurate means of measuring consistency of concrete mixtures has been a serious obstacle to the proper testing and study of concretes in the laboratory. It is unfortunate that there has been no means for properly determining and controlling the water requirments of concrete, since variation in water content has so great an effect on strength. The writer believes that had Professor Abrams and Mr. Edwards been able to properly control and measure this requirement, neither of the proposed theories for the proportioning of concrete mixtures would have been presented to the public in their present form.

The proponents of both theories are agreed that concretes must have the same consistencies to be comparable. In Lewis Institute Bulletin No. 1, Professor Abrams states that the 27 concretes shown in Table 2 had the same consistencies as measured by the cylinder slump test; the column of results marked 100 per cent consistency having slumps of ½ in. to 1 in. as measured by this test. Mr. Edwards in American Society Testing Materials Proceedings for 1918, page 253, states: "The marked influence of consistency of the mix upon the ultimate strength of mortars renders it especially important that test mortars be made of uniform consistency. The importance of this investigation as a preliminary to the making of tests tending to prove or disprove the validity of the primary theory of the surface area method of proportioning is self-evident." Following this statement Mr. Edwards gives the surface area water formula as shown above.

There is no question that both investigators fully recognize the basic requirement that equal consistencies must be obtained, but tests of their own aggregate gradings show that both failed to secure such comparable concretes in practice.

Eight of the aggregates included in Table 2, Lewis Institute Bulletin No. 1, were prepared by screening Potomac River sand and gravel and recombining them to conform with the sieving analyses shown in that table. Concretes were made of the proportion 1:5, using equal quantities of mixing water in all as specified by the Abrams water formula. Both, the cylinder slump test, and the vibrating steel plate, another method used in the laboratory for measuring flowability, indicated wide differences in consistency for these concretes. In two cases the cylinder form was withdrawn and the masses of concrete picked up by hand and carried back to the mixer without losing their shapes. Two other aggregates slumps of 7¾ in. and 8½ in. Later tests showed that these concretes which were described as having equal consistencies actually varied more than 25 per cent in this respect; that is, the amount of water in the wettest of the mixes was more than 25 per cent greater than that required to yield the driest of the mixes. The difference in strength found for these mixes is of secondary importance since concretes differing so widely in consistency are not comparable.

Equally wide variations in consistency were found among mortars made with aggregates having the same gradations as those used by Mr. Edwards. The three aggregates C, E, and G, in Table 7, page 256, of the 1918 American Society Testing Materials Proceedings were reproduced. The quantity of water specified by the Edward's water formula was found to be entirely insufficient. The quantity was increased by a constant in order to obtain mixtures which had some degree of workability, and the resulting wide differences in consistency were apparent to the eye and verified by the flowability test. The test data are shown below:

MIXING WATER.

Aggregate.	Group 1 — Specified by the Edwards formula, w/c constant. cc.	Group 1 — w/c.	Group 2 — As increased to obtain workable mix, w/c const. cc.	Group 2 — w/c.	Group 2 — Rel. flow.	Group 3 — As used to obtain equal flows. cc.	Group 3 — w/c.	Group 3 — Flow.	Compressive strength. Lb. per sq. in.
E	553	.426	720	.555	170	720	.555	170	3,855
C	343	.426	447	.555	125	497	.616	168	3,170
G	178	426	234	.555	*	342	.820	171	1 810

*No flow, not plastic.

In Group 1, the quantity of mixing water specified by the "surface area" water formula was used. The quantity of water supplied was entirely inadequate to result in plastic workable mixes for the aggregates C and G. In Group 2, the quantity of water was increased proportionally for all the aggregates, but G was still too dry to be workable, and the wide variation in consistency obtained for E and C was very marked. It was manifestly improper to mold mortars differing so greatly in consistency, so that flowabilities were made equal as shown in Group 3. This was done by increasing the quantities of mixing water for aggregates C and G.

This series of tests, which confirms the results of others outlined to test the surface area theory, shows conclusively that, (1) the Edward's water formula which results in a constant water-cement ratio (w/c), as proposd by Professor Abrams, is entirely inadequate, and (2) the resulting mortars have wide differences in consistency, so that the strength values obtained are not comparable. The addition of sufficient water to equalize consistencies furnishes mortars which are comparable, but fully discredits the proposed water formula, since the w/c relation is no longer constant. In this particular case, w/c varied from .555 to .820.

A comparison of the amount of water which the Edward's formula would furnish to a 1:3 standard Ottawa sand mortar, as used in the routine testing of cement, is also interesting.

Assume the percentage of mixing waters required for normal consistency of a given cement to be 24.

Surface area of standard Ottawa sand = 400 sq. in. (approx.) per 100 grams.

Assume batch of 500 grams cement and 1,500 grams standard Ottawa sand.

By "surface area" water formula,

$$\text{Water} = .24 \times 500 + \frac{6{,}000}{210} = 148.6 \text{ cc or } 7.42 \text{ per cent.}$$

The United States Government specification for Portland cement specifies 10.5 per cent mixing water for a 1:3 mortar made with such a cement.

$$\text{Water} = 10.5 \times 2{,}000 = 210 \text{ cc.}$$

Those familiar with routine testing of cement are aware that such a mortar with 10.5 per cent mixing water is by no means a flowing, plastic mix, yet the proposed surface area water formula furnishes 61.4 grams or 3.08 per cent less mixing water. Since natural sands often require several per cent more mixing water than standard sand for the same consistency, no further comment should be required.

It is stated that the factor, $\frac{\text{total area}}{210}$, takes into account the varying water requirements due to differences in surface areas of the aggregates. It was shown in the preceding discussion, however, that w/c equals a constant, so that water is actually based only upon the cement content of the mix, while the large variation in surface areas, which the author admits require varying quantities, are disregarded. It is an admitted fact that the granular composition or grading of an aggregate is reflected by the amount of water required to produce concretes of the same flowabilities, but this formula is equivalent to one which bases the water requirement on cement content only, as is shown in the following:

Assume sands A and B having surface areas of 300 and 600 sq. in. per 100 grams, respectively; a cement requiring 25 per cent mixing water for normal consistency; and proportions of 1 gram of cement for each 10 in. of surface area of aggregate:

SAND A—

Quantity of cement .... $\frac{300}{10} = 30$ grams.

Water .... $(30 \times .25) + \frac{300}{210} = 8.93$ cc.

w/c .... $\frac{8.93}{.67 \times 30} = .443.$

Per cent water by weight of cement .... $\frac{8.93}{30} = .297 = 29.7\%.$

SAND B—

Quantity of cement .... $\frac{600}{10} = 60$ grams.

Water .... $(60 \times .25) + \frac{600}{210} = 17.86$ cc.

w/c .... $\frac{17.86}{.67 \times 60} = .443.$

Per cent water by weight of cement .... $\frac{17.86}{60} = .297 = 29.7\%.$

Disregarding the sands for a moment, since the percentage of mixing water based upon the weight of cement is constant, equal consistencies will be obtained for the cements alone, if all the water provided is used.

If, however, the two sands are then added to their respective quantities of neat cement pastes, the mix containing Sand A will be much stiffer and less workable than that containing Sand B. It is of course assumed that the two sands are of the same type, as would result from the screening and recombining any first class sand. The effect on consistency is the same as would result from the addition of an aggregate such as standard Ottawa sand to the first paste, and a silicious beach sand to the second. Less calculation would be required if the water formula were stated in terms of the weight of neat cement only. The above demonstration also shows what occurred when tests of the eight Abrams aggregates, included in Table 2, of Lewis Institute Bulletin No. 1, were tested, since the water formula included in that report provides neat pastes of equal consistency, but makes no provision for the wide differences in surface areas of the aggregates.

As previously stated, tests of the Abrams aggregates resulted in concretes varying greatly in consistency, although the author stated that equal consistencies were obtained. A study of the proposed "fineness modulus" water formula makes clear why such differences in consistency should reult without the employment of the actual tests, which later fully verified the opinion first formed from such a study.

The expression for the quantity of mixing water is as follows:

$$x = w/c = R \left[3/2p + \left(\frac{30}{1.26^m} + a - c \right) n \right]$$

It is stated that with "m" fineness modulus, constant, and "n," proportion of cement to aggregate, constant, the same consistency will result, and the same strength will be obtained, whatever the grading of the aggregate within rather wide limits. As shown in Table 2, Bulletin No. 1, with "m" constant, there may be wide differences in total surface areas of aggregates For the aggregates shown, the variation in surface areas in over 600 per cent. Concreting practice has established the fact that for the same consistency a fine sand requires more mixing water than a coarse sand; that a sand similar to a beach sand requires more than a coarse, well graded, river sand. Inspection of the granular analyses of sands used for concrete work throughout the country indicates that they may vary over several hundred per cent in surface area. In spite of this well understood condition, that a fine aggregate having a relatively high surface area will require more water than a coarse aggregate, it is claimed that the above water formula will result in the same consistency for any group of aggregates having the above conditions constant. Although not expressed in so many words, the Abrams water formula is equivalent to the statement that whatever the gradation, aggregates having the same fineness modulus, although varying as much as 600 per cent in surface area, require the same quantity of mixing water for the same consistency.

The addition of any factor to this formula to properly take into account this variation in surface area of aggregates (a condition which Mr. Edwards also states must be considered, but fails to provide for), will result in different values for w/c for different gradations, thereby destroying the constant w/c relation which is claimed to be the criterion for equal strengths, and thereby undermining the whole theory of "design of mixtures."

Summarizing the foregoing briefly, a study of the test data offered by the proponents of the two theories, checked by tests of similar combinations of aggregates, would seem to establish the following:

Surface Area Theory.

1. The water formula proposed in the surface area theory reduces to a constant water-cement ratio for any fixed relation of cement to surface area of aggregate.
2. The important property of surface area does not enter into the determination of the quantity of mixing water, except insofar as it fixes the quantity of cement at the beginning.
3. The formula is not only incorrect in theory, but is inadequate in practice, and results in mortars and concretes varying widely in consistency, which are, therefore, in no sense comparable on the basis of strength.
4. Tests indicate that compressive strengths increase as the ratio of cement to surface area of aggregate decreases, although such increase is by no means proportional to the decrease of the ratio.

Fineness Modulus Theory.

1. The foundation of this theory is a water formula which gives no consideration to the varying water requirements of aggregates varying in surface area.
2. It is shown that, with a given fineness modulus, the total surface areas of aggregates of different gradings may vary as much as 600 per cent.
3. In spite of this wide difference of surface areas it is claimed that resulting concretes of the same mix will have the same consistency.
4. Tests have shown that the consistencies actually obtained varied more than 25 per cent with the above constant conditions, and such differences were measurable by all known consistency methods, as well as apparent to the eye.
5. The strengths obtained in tests of such concretes are not comparable, since the condition of equal consistency, admitted as necessary and fundamental by the proponent of the theory, cannot result.
6. The addition of any factor to the water formula to properly take into account these varying water requirements destroys the constant water-cement relation which is the criterion for equal strengths.
7. The strength results given in Table 2, Lewis Institute Bulletin No. 1, would seem to discredit the surface area theory as advocated by Mr. Edwards. However, these tests are not competent to either deny or affirm that theory, since equal consistencies were not obtained. The strengths of the concretes would be considerably modified by the addition of sufficient water to result in equal consistencies.

The following comments refer more specifically to Mr. Young's discussion of the two theories.

Mr. Young states that, "The Bureau's . . . tests indicate that for constant flowability the water required varies with the surface area of the aggregate." Our tests show that aggregates of high surface areas require more water than those having smaller areas, but the increase in water is by no means proportional to the increase in area. This is the very factor which neither of the foregoing water formulas take into account.

As to the results which Mr. Young states that Prof. Talbot has obtained, they appear to be quite in accord with our own experience so far as the water requirement is concerned. There are also indications that strengths increase slightly, in some cases at least, with increase in surface of aggregate when cement is proportioned in the usual volume method, but some rather consistent exceptions make it unwise to draw any definite conclusions until additional work is completed.

However, such a conclusion that strength does increase with surface area, is in this case directly opposed to the surface area theory. These concretes referred to were proportioned in the customary way, one volume of cement to so many volumes of aggregate, so that the ratio of cement to surface area decreases as the surface area increases, contrary to the theory proposed by Mr. Edwards.

With reference to the results of the investigations of the Hydro-Electric Power Commission of Ontario, the conclusion that the "fineness modulus" is but another and somewhat approximate method, etc., . . .," is not substantiated by a study of aggregates in common use in various sections of the United States. The wide variations which may be found is well shown in Table 2, of Lewis Institute Bulletin No. 1. As to Conclusion 2, if the cement is proportioned with relation to surface area, the Edward's water formula will result in wide differences in consistency as shown above, while if the cement is proportioned in the customary manner, an increase in strength with increase in surface area is directly opposed to the surface area theory. Conclusion 3 is true beyond doubt, since with the same cement, the same aggregate, and the same age for test, water is the only ingredient to be varied, and the variation in strength with change in water content under such conditions is too well recognized to require proof. Strict adherence to the surface area theory, if sufficient water is supplied to make workable those mixes having low surface areas, will result in very "soupy" consistencies for the richer mixes having the greater surface areas, so that much of the gain in strength which should result will be thrown away.

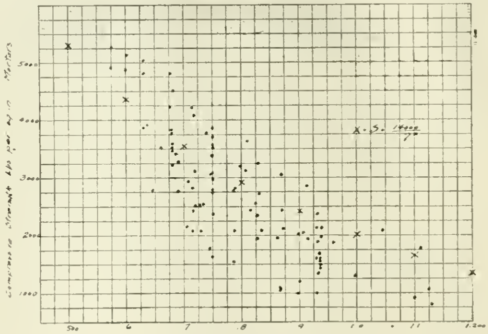

Fig. 1—Data From Technical Paper 58, Bureau of Standards, Table 5.

It is very apparent that "there is no mathematical relation between surface area and fineness modulus" since it has been shown that with a given fineness modulus the surface area may vary more than 600 per cent, while aggregates with any given surface area may have moduli varying considerably. Figure 1, in Mr. Young's article, shows this fact, and were he to plot on this diagram aggregates in use in other localities, he would find the points scattered over a wide zone rather than along a single line. With the wide differences in surface areas which may be had with a given fineness modulus, it is difficult to understand how the expression of this term may be considered as another way of expressing the surface area.

Figure 5 in Mr. Young's article furnished a clear demonstration of the fallacy of averaging tests of concretes, especially when such concretes are not comparable owing to wide differences in consistency. It is clear from a study of this diagram, which has been widely used as a proof of the accuracy of the "fineness modulus" theory, that no consideration has been given to the consistencies of the concretes represented by the plotted points. This diagram has little value beyond showing graphically that the function of increase in mixing water, whatever may be the mix or combination of the aggregates, is to lower compressive strength. With the same mix, cement, and grading of the aggregate, a line may properly be used to indicate the reduction in compressive strength with increase in water content, and the general trend of such a curve will be somewhat like the one shown in the figure. But, even assuming that strict consideration has been given to the necessity for equal consistencies for all concrete included, the variations in compressive strength between mixtures having the same w/c relation is seen to be as high as 50 per cent. The inclusion of more tests will tend to increase this difference. The strength trend as influenced by the amount of mixing water can be best represented by a broad band or zone, rather than by a line.

In Mr. Young's Fig. 7, he shows 6 plotted points which he states were taken from Tech. Paper 58 of the Bureau of Standards, and which he believes indicates the concordance of the results of that report with the conclusions of the two theories. A full study of the tests reported in that paper will in no way confirm his conclusions, but on the other hand, that report furnishes data which controvert the claims of both theories, and shows the fallacy of drawing conclusions from a few tests as has been done in the case of Fig. 7.

In Fig. 1, accompanying, are shown the relation of the water-cement ratios to compressive strengths of the large group of sands included in Table 5, Tech. Paper 58. The results are comparable since the same consistencies were used for all mortars.

In Fig. 2, accompanying, are shown the compressive strength results given in Tables 8, 9, 10, 11, and 12, of the same report, plotted in the same manner. The aggregates used in these tests were mainly limestone and gravel, with a few samples of granite and trap rock. The extremely wide variations in strength for any given value of w c are probably due to the different types of aggregates, but the values for either gravel or limestone, alone, can only be represented by a broad zone, rather than by a line.

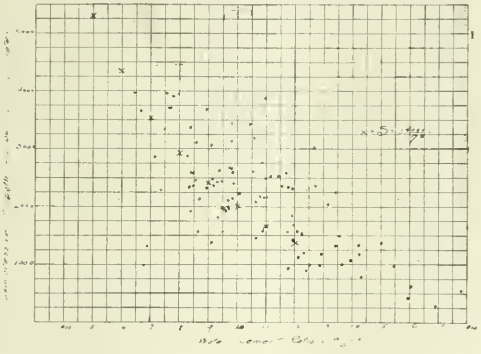

Fig. 2—Data From Technical Paper 58, Bureau of Standards, Tables 8, 9, 10, 11 and 12.

The results given in the above mentioned tables of Tech. Paper 58 furnish evidence to discredit the surface area method of proportioning, as the relations can be seen at a glance without computation which was required for a study of the w/c relation. Two sands differing little in surface areas were generally used with a large number of coarse aggregates, and since the aggregate of a coarse aggregate is usually less than 10 per cent of that of a sand, the total areas of the mixtures do not differ greatly. Therefore for any given proportions, we should expect to obtain equal strengths, but such a relation is not found.

Rather than furnish proof of the accuracies of these two theories, the results included in Tech. Paper 58 still appear to justify the conclusions in that paper: "No standard of compressive strength can be assumed or guaranteed for concrete of any particular proportions made with any aggregate unless all the factors entering into its fabrication are controlled," and, "The relative compressive strength of concrete to be obtained from any given materials can be determined only by actual tests of those materials combined in a concrete." Later tests seem to indicate that the gradation of the sand, which is made of great importance in the surface area theory, is of less consequence than has generally been supposed, although it is a factor which cannot be disregarded

The criticism which Professor Abrams has made of the gradings of the aggregates used in recent Bureau of Standards tests were fully answered in the Aug. 14, 1919, issue of Engineering News-Record. With reference to the aggregates which were included in Table IV, and which were made up similar to those of Table 2, Lewis Institute Bulletin No. 1, the following statement was made:

"The aggregates used in the concretes of Table IV are criticised as being too coarse, probably on account of the low strength results obtained in some cases with the constant water-cement ratio. These low strengths are not due to coarseness but to adherence to the Abrams water formula which provides too much mixing water for the coarse aggregates, resulting in concretes having unequal flows which are not comparable. It should be noted that these so-called poor aggregates 2, 3, 7, and 8, when tested with flows constant, showed good strength increases which indicated them to be the best aggregates in the group. It would seem that any standard of coarseness which would rule out such aggregates must be seriously in error. Aggregates 7 and 8 are criticised as being decidedly freakish, in that all material is contained on the 28 or 48-mesh sieves. This same criticism can equally well be made of the Abrams aggregates 271 and 276, Lewis Institute Bulletin No. 1. However, tests show that all of these aggregates are satisfactory from the standpoint of workability and compressive strength when proper account is taken of flowability."

It seems clear to the writer that no tests, other than those reported by the proponents themselves are required to disprove these theories. Mr. Young's discussion is based upon the assumption that the test data offered by both are correct and fully represent the true values which should be found for the aggregates employed. He disregards the basic requirement of equal consistencies, which is accepted by both proponents, but apparently employed by neither, in obtaining the test data used to support their respective theories.

The writer has attempted in the foregoing discussion to point out what seems to be the fundamental error, both in testing and interpreting the results of the tests reported. Whatever further tests along such lines may show, the test data so far presented seems to discredit both theories. However, a few tests made by those who are interested in the subject of proportioning concrete mixtures will do more to settle the points involved than any amount of discussion. Since the first and main criticism of these theories deals with the question of consistency or flowability, it should be an easy matter for any laboratory equipped with sand sieves to screen and regrade an aggregate to correspond with the gradings used by the advocates of these theories in their work. Reproduction of a few of the mortars and concretes used by each should furnish test data to conclusively affirm or deny their claims.

Moisture Content of Wood Is Independent of Density

Even after long exposure to the same atmospheric conditions, different pieces of wood do not have exactly the same moisture content. Variations of 2 per cent were recently found in red oak blocks stored under carefully fixed humidity conditions at the U. S. Forest Products Laboratory.

These moisture differences, unlike variations in strength, are apparently independent of the density of the pieces. In the laboratory experiments, the variation proved to be as great in blocks of the same density as it was throughout the lot of specimens. Moreover, the range in moisture content was the same in wood of low density as in wood of medium density or high density.

Data on a few representative specimens are given in the following table:

Density of specimen.	Average moisture content in percentage of weight oven dry. Relative humidity at 80° F. 38%.	61%.	88%.
Low—			
.519	7.6	11.2	19.4
.527	6.0	10.0	17.4
.536	6.5	11.0	18.2
Medium—			
.630	7.7	11.3	18.9
.639	5.8	10.7	18.3
.643	6.8	11.3	19.5
High—			
.720	6.4	11.2	19.3
.724	7.4	11.4	19.6
.753	6.1	10.8	18.8
Total average	6.7	11.0	18.8

"Should Architects Advertise?"—In our Dec. 24 issue we printed an article bearing the above title, which we credited to the Architect and Engineer. The editor of that journal informs us that the matter appeared originally in Class, to which the credit should have been given.

Recent Advances in Length of Bridge Spans*

By HENRY S. JACOBY.

Professor of Bridge Engineering in Cornell University.

It is always interesting to notice the gradual increase in the length of spans for the different classes or types of bridges, as an indication of progress in bridge design and construction. This increase is the result of a number of factors: such as improvements in metallurgy and the manufacture of materials; better equipment in bridge works; improved methods and plant for erection; as well as experimental investigations and better designs of members and details of connections. Such improvements are materially stimulated when commercial needs require the use of a bridge that is larger and heavier than any other one of its class previously built. The advantages thus gained are shared later by structures of lesser magnitude.

In Table 1 a list is given of the longest effective spans for different classes of bridges located on the North American continent. The dates in the last column show that 71 per cent of these classes or types had their longest spans increased during the present decade, and of this number 73 per cent were increased during the second half of the decade. The demand for the construction of so many bridges of unusual magnitude within this period could be required only by the transportation system of a prosperous country having large rivers to cross. It will be noticed that all but six in the list are railroad bridges.

Only two of the bridges were built in the nineteenth century. The stone arch bridge was practically displaced in the line of development by the concrete arch bridge many years ago, and hence it is unlikely that its span will be increased beyond the limit of 220 ft. The steel arch bridge at St. Louis, designed and built under the direction of Capt. James B. Eads, represented such an unprecedented advance at that time in its material, design, construction, erection, and cost, that it is not surprising that no larger span of its class has been built since. It may be added that only one steel arch bridge without hinges, with a span exceeding 200 ft., has been erected in this country since 1874, while the entire number of bridges of this type is very small in America.

The longest span for simple plate-girder bridges remained unchanged from 1904 to 1916, although much heavier plate girders were built during that interval. The longest single girder in the Boston & Albany R. R. bridge over the New York, New Haven & Rockford R. R. at Worcester, Mass., weighed 170 tons, and may be properly characterized as the most noteworthy, both in design and construction. Its length over all is 122 ft. 6 in.

The intermediate span of a steel viaduct taken by itself is not so characteristic of progress in viaduct construction as in other classes of bridges. The total length of the Lethbridge viaduct is 5327.6 ft., and its height 314 ft. above the bed of the river. Other American viaducts with spans equal to or greater than 100 ft. have a much shorter total length.

In 1907 the longest span of a simple truss bridge with riveted connections throughout, was 300 ft. 10 in.; in 1908 it was raised to 412 ft. 8 in., when the Canadian Pacific Ry. bridge over the French River was completed; in 1911 the span was raised to 425 ft. 6½ in., upon the completion of the Terminal R. R. bridge over the Missouri River at Kansas City, this being a double-deck bridge for double-track railroad traffic on the lower, and highway traffic on the upper deck. The next increase in span of over 50 per cent to the present value given in the table was due chiefly to unusual requirements for navigation, as finally determined by litigation which was going on while the rest of the bridge was under construction.

The increase in span for the simple truss bridge with pin connections is likewise remarkable. From 1894 to 1906 the longest span was 546 ft. 6 in., that of a bridge at Louisville, Ky., which accommodates a single-track railroad and a highway. In the latter years a light highway bridge was completed at Elizabethtown, O., which brought the span up to 586 ft. Six years later another increase was made to 668 ft. by the erection of the Municipal or Free bridge at St. Louis, Mo., which is a double-deck structure with a double-track railroad on the lower floor. It was supposed that this span would remain the upper limit for a considerable time, but at least two years before the river spans of the Municipal bridge were completed, preliminary designs were begun for a bridge across the Ohio River at Metropolis, and which was completed seven years later, or in 1917. Its channel span of 720 ft. was made a simple truss in order to restrict its deflection under live road to lower limits than a cantilever span would permit.

The longest span of a plate-girder swing bridge was 196 ft. in 1900, 232 ft. in 1909, and was finally increased to 236 ft. as indicated in the table. It is a double-track bridge and could be designed of this length since it was fabricated at the shops of the Dominion Bridge Co., which are located within a few hundred feet of the bridge, thus avoiding the usual limitations due to transportation.

For 15 years the record span of 520 ft. for a swing bridge truss was held by the bridge over the Missouri River at East Omaha, Neb., completed in 1893. The one listed in the table has a span only 1 ft. longer between centers of end bearings, and perhaps no further increase will be made on account of the operating advantages of bascule bridges, the largest of which (No. 10 in the table) provides a greater channel clearance than that of any swing bridge.

After the vertical lift bridge at South Halsted St., Chicago, was built in 1894, with a span of 130 ft., it was a long time until another one was constructed. This was due to the high cost of operation by steam which was the motive power required by the city, contrary to the recommendations of the engineer. When electric power was substituted in 1907, the results were so satisfactory that interest was renewed in the design of this class of bridges. In the bridge over the Mississippi River at Keithsburg, Ill., the spans were made alike (229 ft.) and so arranged that the towers and lifting mechanism could be shifted from one span to another in case the channel in the river required it. Over thirty of these bridges have been built, most of them in the western states.

The longest span of 296 ft. given in the table is not that of the heaviest one, which is located at Portland, Ore., and which is a double-deck structure so arranged that the lower, or railroad deck, may be lifted first for low clearances, after which the entire span may be lifted for the higher clearances. Some idea of the lifting mechanism may be formed from the fact that each sheave weighs 24 tons and each of the four counterweights weighs 856 tons. The lift span in this case is only 211 ft. long.

In the vertical lift bridge at Kansas City given in the table, only the lower or suspended deck carrying a double-track railroad is lifted against the upper deck so as to provide for the limited clearance required. Before the construction of that bridge with its modern mechanism, only very short spans with a movable deck had been built.

Before the single-leaf bascule bridge given in the table was built the longest span was 235 ft., being that of the Baltimore & Ohio R. R. bridge over the Calumet River at South Chicago, completed in 1913. The double-leaf bascule bridge had its span increased from 275 ft. in 1901 to 336 ft. in 1914. The one included in the table is, however, entirely different in its action when closed than those previously built. It acts as a simple truss when closed while other double-leaf bascules act as two cantilevers locked together at the center. The development of bascule bridges in America is almost confined to the past score of years, but few examples of the modern type being in existence at the beginning of that period.

The Aerial Ferry bridge listed in the table is the only one of its kind in this country.

Until they were replaced in 1912-13 the 408-ft. spans of the Canadian Pacific Ry. bridge across the St. Lawrence River, near Montreal, had been the only statically indeterminate continuous trusses on the continent for a period of 25 years. Since the bridge which took its place consists of simple truss spans throughout, it seemed quite unlikely that any other continuous truss bridge would be built for a number of years. Favorable conditions, however, led to the construction of a continuous truss bridge consisting of two spans each 775 ft. long, over the Ohio River, at Sciotoville, as indicated in the table. It was more surprising to find that two others were also under construction in 1917 and were completed during the following year, one over Nelson

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*From the November Cornell Civil Engineer.

River on the Hudson Bay Ry., and the other over the Allegheny River on the Bessemer & Lake Erie R. R., their largest spans being 400 ft. and 520 ft. ½ in., respectively.

The record span for cantilever bridges in America had been held by the Memphis bridge, completed in 1892; then by the Monongahela River bridge at Pittsburgh, finished in 1904; and then by the Queensboro bridge at Blackwell's Island, New York, from 1909 until the Quebec bridge was built. The cantilever spans of these three bridges were 790 ft. 5 in., 812 ft., and 1,182 ft., respectively.

Before the longest suspension bridge span given in the table was erected, the record was held continuously at 1,595 ft. 6 in. by the world-famous Brooklyn bridge ever since its completion in 1883. This bridge was also noted for many years as having the largest passenger traffic of any bridge, of any class, in the world.

In the class of steel arches and of the three-hinged type, the longest span (456 ft.) was in the Marshall Ave. bridge at Minneapolis, Minn., from 1889 to 1901; then it was increased to 540 ft. in the Connecticut River highway bridge at Rockingham, Vt.; the next increase to 591 ft. being made in 1915 when the Detroit-Superior bridge in Cleveland, O., was finished. This last bridge is a double-deck structure consisting of reinforced-concrete arches, with the exception of the single long span mentioned. This span represents the highest development of the three-hinged steel arch bridge, although the light highway bridge given in the table as No. 15, completed a year later, has a span one foot longer.

The longest span of any two-hinged steel arch bridge before the erection of the Hell Gate bridge listed in the table was 840 feet, being that of the upper arch bridge at Niagara Falls, completed in 1898. For one year the record had been held previously by the 550-ft. span of the lower arch bridge over the Niagara River, which is a double-deck bridge with the Grand Trunk R. R. on the top floor.

Before the famous Eads arch bridge at St. Louis was built to which reference was made previously in this paper, the longest span of any steel arch bridge without hinges located in America was only 200 ft., it being that of an interesting bridge on Pennsylvania avenue, in Washington, D. C., which was built in 1858 and replaced in 1916. Its arch ribs consisted of cast-iron pipes which conveyed a water supply across Rock Creek, while the deck of the structure carried ordinary highway traffic.

The term "plain concrete arch" as used in the table refers to one in which no steel is used to aid the concrete in the arch rib to resist dead or live load stresses, but in which a small amount of steel may be used for the prevention of cracks due to temperature. From 1907 to 1910 the longest clear span in a concrete arch bridge of this type was 233 ft., being that of the Walnut Lane bridge in Fairmount Park, Philadelphia. In 1910 the record passed to the bridge over Rocky River near Cleveland, O., its span being 280 ft., and a year later to the one given in the table as No. 19.

TABLE I—LONGEST SPANS FOR DIFFERENT CLASSES OF AMERICAN BRIDGES.

No.	Class of bridge.	Span. Ft.	Span. In.	Location.	Date of completion.
1	Simple plate girder	130	6½	Grand Crossing, Ill.: Nickel Plate R. R.	1916
2	Steel viaduct	100	0	Lethbridge, Alberta; C. P. Ry.	1909
3	Simple truss, riveted	643	10½	Louisville, Ky.; Penn. Lines	1919
4	Simple truss, pin	720	0	Metropolis, Ill.; C. B. & Q. and N. C. & St. L. Ry.	1917
5	Swing, plate girder	236	0	Over Lachine Canal, n. Montreal; C. P. Ry.	1915
6	Swing, truss	521	0	Portland, Ore.; N. P. Ry.	1908
7	Vertical lift	296	0	N. Mondak, Mon.; Great North. Ry.	1914
8	Vertical lift (floor only)	428	0	Kansas City, Mo.: Terminal R. R.	1911
9	Bascule, single leaf	260	0	Chicago, Ill.; St. Charles Air Line Ry.	1919
10	Bascule, double leaf	336	0	Sault Ste. Marie; C. P. Ry.	1914
11	Aerial ferry	393	9	Duluth, Minn.; over U. S. Ship Canal	1905
12	Continuous truss	775	0	Sciotoville, O.; C. & O. N. R. R.	1917
13	Cantilever	1,800	0	n. Quebec, Can.; Grand Trunk R. R.	1917
14	Suspension	1,600	0	N. Y. City; Williamsburgh Bridge	1904
15	Steel arch—3-hinged	592	0	Needles, Calif.; highway over Colorado River	1916
16	Steel arch—2-hinged	977	6	Hell Gate, N. Y. City; N. Y. Connecting R. R.	1917
17	Steel arch—No hinged	519	9⅜	St. Louis, Mo.; Pennsylvania Lines	1874
18	Stone arch	220	0	n. Washington, D. C.; Aqueduct bridge	1864
19	Plain concrete arch	281	0	Monroe St., Spokane, Wash.	1911
20	Reinforced concrete arch	300	4⅞	Larimer Ave., Pittsburgh, Pa.	1912
21	Concrete viaduct	180	0	Nicholson, Pa.; Lackawanna R. R.	1915

In 1912 a reinforced-concrete arch bridge was completed in this country with a larger span than that mentioned in the preceding paragraph. It was the Larimer avenue bridge in Pittsburgh, Pa., with a clear span of 300 ft. 4⅞ in. A design has been made for a 400-ft. span which is to be the channel span of a bridge across the Mississippi River at Franklin avenue, Minneapolis, Minn. The bridge is now under construction.

The statement made regarding steel viaducts applies likewise to reinforced-concrete viaducts. The Tunkhannock viaduct (No. 21 in the table) is a double-track structure, has a total length of 2,230 ft., contains 164,000 cu. yd. of concrete and 1,140 tons of reinforcing steel, while the top of the track rail is 240 ft. above the bed of Tunkhannock Creek. Other concrete viaducts of lighter construction are much longer from end to end, while still others may have a larger span but none of them approach this one in mass.

It may be interesting to add a paragraph on those bridges in other lands which have larger spans than any bridges in America belonging to the same class. There are longer simple plate girders than those in America, but they are of much lighter construction. The published records are not complete enough to identify the one which has the maximum span. There are transporter bridges in England, France, and other European countries having a movable car, but the longest span of approximately 1,000 ft. uses a light suspension bridge to support the track instead of a simple truss bridge as in No. 11 of the table. The longest span of any steel arch bridge without hinges crosses the Wupper River between Remscheid and Solingen in Germany. Its span is 558 ft., and the bridge was completed in 1897. The longest clear span of any stone arch bridge in the world is 295.3 ft. It is located at Planen in Saxony and was finished in 1905. The longest clear span of any reinforced-concrete arch bridge in the world is 328.1 ft., being that of a very light highway bridge across the River Tiber at Rome, Italy, completed in 1911. There are two other bridges of the same class with longer spans than the Larimer avenue bridge in Pittsburgh: one is located at Grafton, Auckland, New Zealand, with a span of 320 ft., and the other at Langwiez, Switzerland, with a span of 314.9 ft.; their years of completion being 1910 and 1913, respectively.

The adoption of alloy steels, after thorough chemical and physical investigations, has had an important part in the economic construction of some of the long-span bridges included in the table. Nickel steel was the first to be introduced and has been used in the Queensboro cantilever and the Manhattan suspension bridges at New York, the Terminal Railroad bridge at Kansas City, the Municipal bridge at St. Louis, the Quebec cantilever bridge, the Detroit-Superior arch bridge at Cleveland, and in the eyebars of the Metropolis bridge. High-carbon steel was employed in the Hell Gate arch bridge and in the continuous truss bridge at Sciotoville. Steel high in silicon was adopted for the riveted members of the Metropolis bridge; Mayari steel, a low-grade natural alloy with nickel and chromium, was used for the Harahan cantilever bridge at Memphis; and a special steel was employed for the continuous truss bridge of the Bessemer & Lake Erie R. R., the characteristics of which have not been published.

It is a very remarkable fact that several of the bridges of great magnitude which are mentioned in this paper were under construction at the same time. In this group are included the longest simple truss span, the longest continuous truss span, the longest cantilever span, and the longest steel arch span; all of them being the longest spans in the world in their respective classes. An inspection of the table will indicate that the longest spans in several other classes were also completed during the period of construction of the greater structures named.

At the same time that the lengths of span have been steadily increasing, and the alloy steels have come into use, the live loads specified have also continued to increase. For a decade E60 loading has been adopted for important railroad bridges, but recently this has been exceeded in several cases. In designing the Metropolis bridge, the specified live load consisted of E90 locomotives followed by an E75 train, but the working unit-stresses were also raised above the usual values; however, in the case of the Bessemer and Lake Erie R. R. continuous truss bridge, the live load was Cooper's E75 loading while relatively low unit-stresses were adopted.

The statement made in the last sentence of the first paragraph of this paper received an unexpected confirmation about a week after it was written when the long-delayed issue of Engineering News-Record for October 2, 1919, was received. It contains an article on "Unusual Design and Joint Details of a 430-Foot Bridge." In this case built-up members of high-carbon steel were used in conjunction with heat-treated eye-bars for the end diagonals and lower chord members, requiring special joint details at the lower chord pins. A Warren type of truss with sub-verticals and a curved upper chord was adopted, it being possible to avoid sub-divided panels by using panels 43 ft. long, with deep stringers, and floor-beams. Expansion joints are provided in the steel floor system by double floor-beams at two intermediate panel points and in each panel of the solid reinforced-concrete ballasted double-track floor. Skid girders are also provided like those introduced in 1910 on the Pittsburgh & Lake Erie R. R. cantilever bridge at Beaver, Pa.

Protection of Wooden Bridges from Fire

Ninety per cent of the fires in wooden bridges and trestles of railways are caused by locomotive sparks, either from the smokestacks or the ash pan, according to a committee report submitted at the annual convention last November of the Railway Fire Protective Association.

Preventive Measures.—Meaures for preventing these fires were recommended as follows by the committee:

That effective spark screens be provided in the front end of all locomotives and carefully maintained.

That ash pans and grates be made tight and kept in good working order, as the dropping of hot coals or ashes is a source of a large amount of our trouble.

That special places be provided for the dumping of cinders and ashes, and grates are not to be shaken down except at safe points.

That all combustible refuse, such as dry leaves, dead grass, weeds, brush and rubbish, be cleared away from under and around all wooden bridges.

That the decks of all wooden bridges, between the rails, be covered with No. 22 galvanized iron, this to prevent sparks from setting fire to the structure should they be dropped from the locomotive.

As a further preventive measure, it is recommended that all wooden bridges be coated with a fireproof or fire-retardent paint, demonstration having proven some of them to be of excellent protection, and that they can be applied at a cost no greater than that of ordinary paint.

Fire Fighting Equipment.—The committee also recommended that one water barrel and one pail be provided for all wooden bridges of a length of 50 ft. or less, and two water barrels and two pails, one to each barrel, be provided for all bridges whose length is more than 50 ft. up to a length of 150 ft., and that one water barrel and one pail be provided for each additional 150 ft.

That where a bridge requires one or two barrels and pails the same are to be placed at the ends of the bridge, located at proper clearance from the track and buried in the ground to within 6 in. of the top, and where barrels and pails are located in the middle of the bridge they are to be located at proper clearance from the rails and the top of the barrel is to be provided with a wooden or galvanized iron cover.

In the past great difficulty has been experienced in keeping pails intact with the water barrels, especially where galvanized iron pails or fire buckets have been used, and they are invariably missing when wanted, and it is therefore recommended that a square wooden bucket of unfinished lumber be provided and that the same be suspended in the water inside of the barrel.

As a further means of extinguishing the blaze, it is recommended that all locomotives be equipped with fire-fighting apparatus so that they may cope with the situation should occasion arise.

Wrecking Old Stone Buildings With Dynamite

By M. C. POTTER.

In demolishing old stone buildings with dynamite, the location of the structure will govern the method employed. A building standing away off by itself can be given rougher and quicker treatment than one standing near other buildings that would be damaged by flying stone or debris.

Assuming that the building stands in an isolated position; I would proceed to put down bore holes all around the outside of the foundation walls spacing them 3 to 4 ft. apart and going down into the ground approximately 4 ft. The holes should be so placed as to make it possible to get the charges of dynamite right up against the foundation walls.

A ½ or a ¼ lb. charge of dynamite should first be set off in the bottom of each of these bore holes for the purpose of forming a cavity into which 5 to 10 lb. of dynamite can be loaded. The preliminary charges need not be tamped in. The larger finishing charges should be tightly tamped. An electric blasting cap should be imbedded in one of the cartridges going into each charge.

Then going inside the building, place a 25 or 50 lb. box of dynamite in each corner of the cellar right up against the walls. The size of the charge, of course, depends upon the thickness of the walls and the size of the house. It is only necessary to remove from the box the one cartridge in which the electric blasting cap is inserted. After the cartridge has been primed, it can be placed back in the box in its original position. Each of these corner charges should then be covered with moist earth to a depth of about 2 ft. well packed down over the charge.

Similar charges can be placed on the first floor of the house in the corners, covered with earth in the same way.

Most old stone houses have open fireplaces. These, as a rule, are of most substantial masonry construction. It will be found effective to place a box of dynamite in each fireplace, covering it with moist earth in the same way as described above.

After all charges have been located, all charges should be connected up together in series by means of electric blasting cap wires and pieces of copper connecting wire. Great care should be exercised that there are no breaks in the circuit and that every charge throughout the inside and outside of the building are included in the circuit.

The open ends of the circuit are connected to Duplex leading wire which should be at least 500 ft. long extending to a blasting machine that should be located in a sheltered place from which the blaster may operate safely. When all is in readiness, the blasting machine can be operated.

As a general rule, the result of a shot of the type described will be the complete collapse of the building. Most of the stone will be found in a heap in what had been the cellar with the roof lying on top of the pile.

If it is desired to save the roof timber, it will be best to remove it before the blasting as it usually becomes splintered and broken by the fall and by having pieces of stone shot through it.

The stone itself is seldom injured. Of course, some of the stones coming in direct contact with the blasts will be broken into smaller pieces, but nearly all of the stone can be again used for rebuilding.

If a building stands so near to other structures that this method cannot be employed, it is desirable first to remove the roof. Then beginning at the top of the structure, drill holes into the mortar between rocks and tamp into these holes small charges of dynamite. From ⅛ to ¼ lb. of dynamite in each hole is usually a proper charge. However, that depends upon how near the contiguous buildings may be. The further away, the larger the charges that may be used.

Before firing these charges, it is usually well to cover them with blasting mats made either of heavy rope, or of home-made construction consisting in binding together in some way a number of burlap bags which should be saturated with water to make them as heavy as possible. This will prevent pieces of rock from flying and breaking windows or damaging roofs of nearby buildings.

SCIENCE OF MANAGEMENT

Application in Civil Engineering and Construction Fields

The term Science of Management was coined by the editor of Engineering and Contracting and first used in "Cost Analysis Engineering" (1908) and explained more fully in "Cost Keeping and Management Engineering" (1909). The last named book, which contains ten laws of management and many subsidiary principles, was the first book on the science of management. In the columns of this journal many additional laws. principles and detail methods of management have been published. This section, which appears weekly, may be regarded as a serial sequel to the two books above named.

Application of Wage Bonus Plan to Construction Operations

Thorough testing of the value of bonus systems on construction work within the next few years seems very probable, as results secured in other industries by this means become more widely known. In the instances to date where a successful plan of paying bonuses to laborers and foremen on outdoor work has been evolved, the basis of the system has usually been the standard time and bonus method of wage payment.

This plan is based upon the establishment of a standard time for the performance of a certain amount of work, and when this set task has been accomplished, the payment of a substantial bonus for additional work done. In this way the workman is assured of a fair wage every day even should conditions be unfavorable for a large output, and then at other times he is enabled to earn higher wages than would otherwise be possible.

Since the work done by a gang of men is the result of joint effort, the performance per cent for the entire gang is the factor that determines the bonus for each man. Further, the bonus percentage for the gang is the bonus percentage for the foreman and is applied to his salary for the pay period, thereby furnishing him with an effective incentive to secure rapid and efficient work. In a statement prepared by W. C. Nisbet of the Emerson Engineers, New York City, for the Committee on Methods of the Associated General Contractors, some applications of this time standard and bonus method in construction operations are cited. The statement is printed in the January Bulletin of the Association, from which the matter following is abstracted.

Hand Excavation on Railroad Cut.—Digging a short ditch through a railroad cut, with trains in operation. Hand work loading into small dump cars, hauled out by boy and mule.

Those in charge decided on the method and a number of men who could work to advantage, then set the time standard, which was, let us say, 5 men for 13 days, or 65 man days. Then suppose the job actually took 70 man days—the efficiency attained was 65 divided by 70, or 93 per cent. This would pay a bonus to all hands, including foreman and mule driver, of 13 per cent on their wages, as reference to the second table below will show.

	Rate per day.	Time.	Wages.	Bonus.	Total.
Foreman	$5.00	14 days	$70.00	$9.10	$79.10
Laborer	4.00	14 days	56.00	7.28	63.28
Boy	3.00	14 days	42.00	5.46	47.46

If one laborer at $4 per day laid off ½ day, his earnings would then be $4 times 12½ days, or $50 in wages with a bonus of $6.50, or a total of $56.50.

The bonus percentages for various efficiencies are as follows:

Efficiency. Per cent.	Bonus. Per cent.	Efficiency Per cent.	Bonus. Per cent.
75	1.0	90	10
76	1.6	91	11
77	2.0	92	12
78	2.4	93	13
79	2.8	94	14
80	3.3	95	15
81	3.8	96	16
82	4.3	97	17
83	5.0	98	18
84	5.5	99	19
85	6.0	100	20
86	7.0	101	21
87	7.6	102	22
88	8.4	103	23
89	9.2	105	25

Surfacing New Railroad Track.—Ballast and surface a piece of new railroad track: Suppose the grade is finished, ties placed, rails spiked and bolted and ballast dumped on the track. Gang of 14 men with a foreman comes on the job to raise and to surface to grade stakes. The standard is, let us say, .055 man hours per foot of track. At the end of a two-week period, when wages are computed, suppose the gang has actually put in 1,950 hours (15 men times 10 hours per day times 13 days), and that they have raised and completely surfaced 7 miles of track or 36,960 ft. The standard hours to be compared to the 1,950 actual hours are then 39,960 ft. times .055 man hours per foot, or 2,031 standard hours; 2,031 divided by 1,950 gives an efficiency per cent of 104 per cent. This pays a bonus of 24 per cent on the wages of each individual in the gang for the pay period in question.

In this case some one may ask how is it possible to determine whether the workmanship is acceptable. Some one must pass upon the acceptability of all work done, whether on bonus or otherwise. We have standards of quality, whether written in specifications and drawn on tracings or simply implied and enforced by inspection. The laborers and gang have to be impressed that the work must be done according to the usual standards of quality. In rare instances trackmen have had to be impressed with this by causing them to lose their bonus or requiring that they do the work over without a bonus.

Carpenters on Bridge Work.—Foreman and 12 bridge carpenters assigned to build new deck and install deck on new bridge. Air compressor and pneumatic equipment for boring and tapping furnished.

To illustrate the method of computing wages, suppose that the foreman got $7 per day, that 13 bridge carpenters got $6 per day each, that one man received $5 per day to dress tools, etc., and that one man received $4 per day to tend the air compressor. Assume a standard of 2 days' time for each foot of finished bridge deck and that at the end of a pay period of 13 working days they had completed 905 ft.

The actual days of labor were, say, 16x13, or 208; the standard days of labor were 905 ft. x .2, or 181; the efficiency was 87 per cent (standard 181 divided by actual 208), which pays a bonus of 8 per cent on wages.

	Wages.	Bonus.	Total.
Foreman	$91.00	$7.28	$98.28
Bridge carpenter	78.00	6.24	84.24
Man to dress tools	65.00	5.20	70.20
Man to tend compressor	52.00	4.16	56.16

Construct Concrete Arch Bridge.—Build a small concrete arch bridge for new line of railroad. (a) Dig foundations.

Suppose, on examination, here a standard is set of .25 of a man day per yard of excavation. If six men and a foreman completed the job in 8 working days with a yardage of 230 yd., the computation for bonus payment would be as follows:

Seven men for 8 days, equals 56 actual days and 230 yd. times .25 man days per yard equals 57.5 standard days. This gives an efficiency per cent of 103 (standard 57.5 divided by actual 56), which in turn entitles all hands to a bonus on their wages earned during the period, of 23 per cent. Now, in practice this bonus per cent and the bonus in dollars is not computed for each job separately, but rather by pay periods, and to illustrate how different jobs are combined, we will suppose the gang mentioned above spends the remainder of the time in the pay period in unloading and storing sacked cement.

(b) Unload and store sacked cement. Suppose six men and foreman (same gang as above) worked four days and unloaded, trucked and stored 8 cars of cement, for which a standard had been set of 3 man days per car. Their actual time is 7 men for 4 days, equals 28 man days and the standard is 8 cars times 3 man days per car, or 24 man days. If the 84 days covered constituted a two-week pay period, the wage and bonus earnings would be something like this:

	Standard days.	Actual days.	Efficiency (Per cent).
Job No. 1	57.5	56	..
Job No. 2	24	28	..
Total	81.5	84	97

Bonus per cent for efficiency of 97 per cent is 17 per cent of wages; therefore the wages and bonus would be as follows:

	Bonus.	Total.
Foreman, $5 per day for 12 days, or $60	$10.20	$70.20
6 men, each $4 per day for 12 days, or $48	8.16	56.16

(c) Build forms (carpenters). Suppose carpenters now go to work on the forms.

To illustrate such a condition we will assume that the job was started at the beginning of a pay period and at the end of the period was not yet completed, but that 2,000 sq. ft. had been put in place, that the number of men engaged was four plus a foreman, and that the standard was .025 days per square foot. The actual man days were then 5 men for 12 days, or 60, and the standard was 2,000 sq. ft. times .025 man days per square foot, or 50 man days. The efficiency on the job then was the standard of 50 divided by the actual 60, or 83 per cent.

Standards Should Cover Small Gang Only.—It is most desirable to have the standards cover individuals only where this can be done, separating the operations into parts. Although this makes more clerical work it is certain to stimulate the workmen to do their best. The next best plan is to have the standards separated so as to cover the work of small groups. If any drones are in the gang the others will raise a noise and ask to have them replaced if a bonus is involved.

It is not advisable to set standards covering the work of over 30 men in a gang. When more than that are included in one efficiency standard, the effect is lessened. In such cases it becomes something like a profit-sharing plan where all workers share alike in the annual profits. The possibilities in profit-sharing plans are too distant, too vague and not directly tied in with the work of any one individual, hence their effect is not very great.

Some suggested units of productions are as follows: In excavation, cubic yards removed; in railway construction, feet of track or number of ties or rails laid; in masonry, cubic yards in place; in building construction, if concrete, feet of floor laid; if steel, tons or lineal feet in place; if wood, square or cubic feet in place.

It is understood that this method entails more clerical work than is needed where straight hourly wages are paid. However, as by its means a reduction of 15 to 25 per cent in labor cost is often attained, the extra cost of the clerical and other supervision is well expended. Contractors should bear in mind that this has been proved to be an excellent means of increasing output per workman in many industries, and that at a time such as the present when greater production is essential to prosperity, every effort should be made to conduct their operations more efficiently.

Idaho Society of Engineers Amalgamated with A. A. E.—The Idaho Society of Engineers was reorganized as The Idaho Chapter of The American Association of Engineers at the annual meeting held at Pocatello, Jan. 12th. A charter granting state jurisdiction to the Idaho Chapter has been issued by national headquarters, but the constitution and by-laws adopted at the Pocatello meeting provide for the formation of local clubs having broad prerogatives as to their own activities. By the action taken at the annual meeting, every member of the Idaho Society of Engineers who so desires automatically becomes a member of the American Association of Engineers and every member of the Association of Engineers in Idaho becomes a member of the Idaho Chapter. The following officers were elected for the first year: President, E. B. Darlington, Chief Engineer North Side Land & Water Co., Jerome; first vice-president, Dr. C. N. Little, Dean of Engineering, State University, Moscow; second vice-president, E. E. Mobley, Bridge Engineer, Oregon Short Line Railroad, Pocatello; secretary-treasurer, Capt. E. S. Ayers, State Highway Department, Boise; executive committee, J. H. Wilson, City Engineer, Idaho Falls; Barry Dibble, Project Manager, U. S. Reclamation Service, Burley; Allen C. Merrit, Mining Engineer, Salmon City.

"Industrial Democracy Pleases Men"

Let us not grow weary of the attention bestowed upon industrial relations by both technical and popular press; for the rapid and radical changes now occurring in this matter of transcendent importance at once both furnish and demand an ever new supply of data, analyses, tentative working rules, and theories. Only as these items are furnished in abundance; studied, discussed, tried, and proved, will there be progress toward the much-to-be-desired condition of stability. Engineering and Contracting, therefore, makes no apology for the frequency with which it may publish articles on this subject, nor the fact that many of them deal with similar phases, and present data of similar character; for the necessary growth cannot be attained without the consumption and digestion of a vast quantity of material.

Under the title with which this article is headed, "Rock Products" for Oct. 11, 1919, presents an article by Mr. B. C. Forbes, setting forth chiefly the employes' view of the operation of the "Leitch Plan" in the tobacco pipe plant of William Demuth & Co. Mr. Forbes says:

Here is a little statement made, not by an employer, but by one of the ordinary workers in the Demuth plant, Harry Liebold, the representative of the amber-mounting department:

"I have seen Industrial Democracy in operation at this factory for the past two years and the main reason I am for it heart and soul is because I know that through it I can always get a square deal.

"When a man in my department has a grievance, he comes to me and tells me about it, and he knows that I will take the question up at the next meeting of the House of Representatives, and consequently the foremen in the Senate and the 'bosses' in the Cabinet will hear about it. They will act on it one way or another, and my experience has been that every question has been settled fairly. Before we had Industrial Democracy, a man with any cause for dissatisfaction would most likely keep it to himself or tell the other workers about it. Perhaps the manager would be too busy to listen to him, so he would nurse his grievance and very likely he would quit. Industrial Democracy prevents just such little troubles before they get big.

"Nowadays at the plant you never hear a foreman urging the men to get on the job. There is no need for it. We all know that by doing our best all the time we are increasing our own dividend. Now whenever a man 'knocks off' early, comes in late or takes a holiday, it is not the boss that wants to know the reason why, but the other men and women workers whose dividends he is lowering.

"Before Industrial Democracy was put into effect it was every man for himself; now it is all for one and one for all.

"I have been in this shop for twenty years and I have never seen the desire to co-operate with the other departments and help the other fellow out so strong as it is now.

"Years ago if a worker had a grudge against the foreman he would probably lay down on the job whenever he thought he wasn't being watched; but that is a thing of the past, for whatever complaints a man has are now always quickly settled in a way satisfactory to everybody.

"Another thing: Industrial Democracy has proven that some of our men had stored up in their minds ideas for new machinery and other labor-saving devices; but they kept these plans to themselves. They were not sure of their reception by the management. Now a man with a good idea knows that not only will his suggestion be welcomed, but that, if practical, it will be rewarded. In our plant today labor and time-saving machinery invented by the men is lowering the costs, increasing production and thus earning dividends.

"Industrial Democracy has given us our voice in the management of the shop; it has given us a lunch room where we can get good meals for 20 cents; it has made this shop a better place to work in; it is teaching English to our foreigners and helping them to become Americans; it has taught us that the firm has troubles and worries just the same as we have, and that by working and co-operating together we all benefit.

"That is what I think of Industrial Democracy as I see it at the Demuth plant, and I think all of the 900 workers here agree with me."

In commenting upon a meeting of the "House of Representatives" which he attended, Mr. Forbes speaks in particular of the discussions of practical problems by the workers. One of these is as follows:

Another subject discussed was whether it would expedite the movement of pipes-in-the-making in their progress through the factory if a great many more trays were furnished. Some representatives contended that the greater the number of trays, the greater tendency to let the pipes accumulate. Every angle of the question was discussed, and I could not help but remark how valuable such practical discussions must prove for the executives—a full record of the proceedings is kept and made available to all.

* * * * * *

Recently I paid a visit in company with John Leitch to one of the plants operating under Industrial Democracy. Mr. Leitch consented to show me through the place, and I was impressed by the attitude manifested toward him by the workers. As a rule, the moment they saw him enter the door of their department they raised a vigorous cheer.

I questioned Mr. Leitch and he told me that in that particular department, where the work was monotonous and trying, he had a little while before made a suggestion to the workers that on the stroke of ten every forenoon and again in the afternoon, they all "go on strike for five minutes," throw open all windows, and relax or amuse themselves in any way they wished. They were all piece-workers and had had some doubts as to whether their earnings would suffer from this loss of 55 minutes a week. But the experiment had proved entirely successful. Hence the exuberant reception accorded him.

Worker's Viewpoint of Labor Problems

Opinions that should prove of great interest to employers and should be of material assistance in enabling them to understand some of their labor problems, are given in a recent report of Bloomfields Labor Digest. The report gives an account of the experiences of Mr. Whiting Williams, vice-president of the Hydraulic Pressed Steel Co., who recently spent seven months in the guise of a worker, and under an assumed name, as a laborer in several large steel plants, shipyards, coal mines and many similar industrial establishments. He applied for work at a large number of plants and mines, and observed carefully the treatment accorded him and other applicants by their employment officers and foremen. At all times he lived the life of the ordinary workers, so that he was able to understand their ideas and appreciate their living conditions.

Mr. Williams believes that the outstanding elements in the worker's mind are as follows:

"The pre-eminent importance of having a job—the dreadfulness of the threat of joblessness under which thousands of workers, particularly the unskilled, live week after week and year after year. It is impossible to overstate this importance. A steady job is more important to the worker than the rate of wages. The present 'joy riding' from one job to another is only a symptom of the relief which comes from a temporary let-up of the strain which under normal conditions keeps a worker constantly in the same place; it should not blind employers to the absolute necessity of regular daily earnings on the part of the best class of workers—those having families. This prime importance of the job makes highly questionable the practice wherever it exists of giving to a foreman, with little or no practical recourse or appeal from his decision, the right of firing; the right in other words of life or death, industrially speaking, over the worker.

"The twins—the unheavenly twins—known as Tiredness and Temper—weary muscle and unhappy mind—soreness of body and soreness of spirit. They may be born of improper work, over-long hours, or bad living conditions.

"The worker's—especially the unskilled worker's—colossal ignorance of his employer's real purposes and character. The meager information ordinarily given him by his employer through the spoken or printed word forces the worker to judge by details of which the employer may be unconscious but which perhaps represent him more truly than words—with, generally, a resultant lack of interest in the work and a more or less pronounced distrust of the employer, including a deep-set conviction that 'pull' secures more recognition than steady, efficient service.

"To these three are to be added other factors more or less common to the entire public: (1) the feeling that the high cost of living is somehow getting the best of us; (2) that the wallets of some are getting fatter as others' dollars grow thinner; (3) that ending the war should end abnormal conditions and, somewhow, hasn't; (4) that European unrest and happenings may affect us all unfavorably in some unexpected way."

Regarding radicalism among the workers, Mr. Williams states:

"With all this, the worker is not a Bolshevist—not yet. But of it the Bolshevist agitator is taking direct advantage. This country, like all others, is staging the greatest selling contest the world has ever seen. The agitator understands his customer better than the competing salesman, the employer. He knows the service the unskilled and particularly the foreign laborer is performing and thoroughly understands the importance of the steady job, and the opportunity for finding mental sore spots caused by physical fatigue and by the absence of mutual understanding between employer and employe. Into these sore spots he rubs salt. Without them the agitator is harmless. As long as thoughtless employers supply him with 'talking points' his sales campaign will prove disturbing to the good employers and dangerous to the entire country. The only effective counter-campaign is for every employer to 'set his house in order' and to persuade his neighbor employer to do the same. All must use the worker's other ear."

Stirring Paint by Compressed Air.—A writer in a recent issue of Factory calls attention to an important use of compressed air in large paint shops. Nearly all large plants, he says, have paint rooms of their own. Here is stored the paint supply of the whole factory. Because of the tendency of the paint to settle, it must be stirred up each time any quantity is withdrawn. As a rule, the stirring of paints by hand is done to the accompaniment of aching muscles and breaking backs. One good-sized factory, however, performs the whole operation by the turn of an air-cock. There happens to be a high-pressure air supply handy to the paint room. Paint is kept in barrels each containing a double wooden paddle. When the paint requires stirring, a pneumatic reaming tool is slipped over the end of the paddle shaft which projects above the barrel top. This shaft is held in place by two crossed pieces placed across the barrel head. By using the shaft in place of a reamer shank, the paddle is whirled rapidly and the paint mixed in a surprisingly short time. After one barrel of paint is mixed thoroughy the reaming tool is slipped over the paddle shaft in the next barrel. Thus the whole job is done quickly and with little labor.

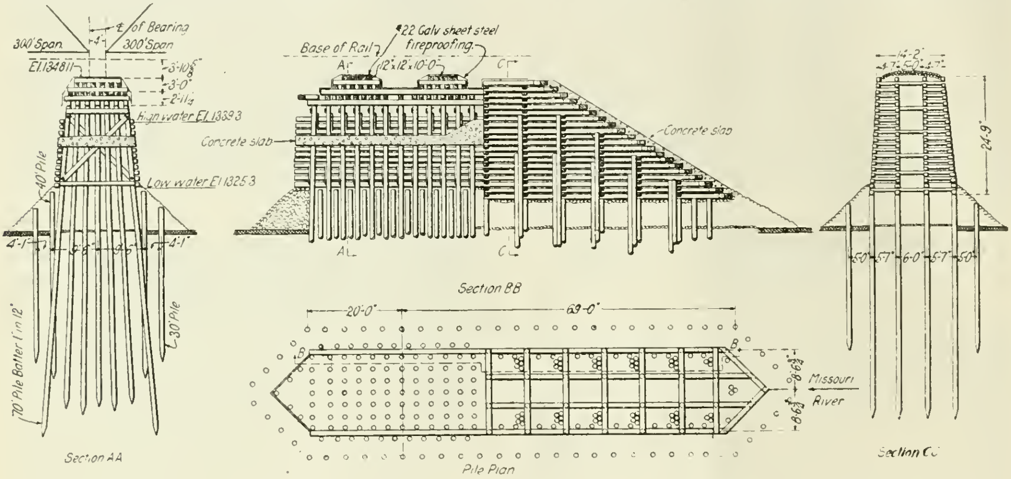
National Conference on Concrete House Construction.—From Feb. 17 to 19 inclusive, there will be held at the Auditorium Hotel in Chicago, a national conference on concrete house construction. The purpose of the conference is two-fold: First, to consider the housing problem in the United States and Canada, and second, to present, crystallize and make available information regarding the most modern practice in the construction of concrete houses and concrete housing projects. Among the organizations cooperating in this movement are the American Concrete Institute, the Associated General Contractors of America, the Concrete Products Association, the Portland Cement Association, the Illinois Society of Architects, the Illinois Chapter of the American Institute of Architects, the U. S. League of Building and Loan Associations. During the week in which the conference meets there will also meet at the Auditorium Hotel the American Concrete Institute, the Concrete Products Association, the Concrete Block Machinery Association and the American Concrete Pipe Association.

Fabricating Shop Contracts in December.—The records of the Bridge Builders & Structural Society as collected by its secretary show that during the month of December, 1919, 85 per cent of the entire capacity of the bridge and structural shops of the country was contracted for.

Pile Piers Support 300 Ft. Steel Truss Spans

An illustration of engineering practice under wartime conditions is to be found in the recently completed bridge of the C., M. & St. P. R. R. over the Missouri River at Chamberlain, S. Dak. It not only embodies the extraordinary use of pile piers as supports for 300 ft. steel truss spans, but it also involves an interesting combination of reinforced concrete and timber construction as the most effective solution of a difficult engineering problem. The following account of the work is abstracted from the Railway Age:

The crossing of the Missouri River serves the Black Hills' division of the St. Paul, a light traffic line extending 219 miles west to Rapid City, S. Dak. Built in 1905 and 1906 through undeveloped territory, the line did not have promise of sufficient traffic to warrant the outlay necessary for a permanent bridge at that time. The original structure gave good service until 1918, when the pontoon, which has seen 13 years of severe service, developed leaks and was put out of commission. A temporary girder swing span served until the present structure was built.



Plan and Section of One of the Pile Piers and Its Ice Breaker.

While the maintenance of a temporary structure had been the source of no little trouble to the railroad because of periodic floods of protracted duration, the construction of a permanent bridge was open to serious objection, not only because of the established war policy of the government—and particularly the Railroad Administration—to discourage any undertaking that would interfere with the directing of all national energies to the winning of the war, but also because the bridge site is in many ways unfavorable to permanent construction. Foundation conditions are such as to require a very expensive substructure, entailing large expenditure both in money and in labor and a long construction period. The location of the crossing is also subject to objections. Certain characteristics of the river upstream from the bridge indicated the desirability of a better location for a permanent structure, and the change of line which this would involve was out of the question under war conditions. As a consequence, it was highly desirable to avoid the use of masonry piers if a substitute construction could be designed that would meet the requirements imposed by the unfavorable characteristics of the Missouri River.

The bottom of the river is a deep bed of alluvial silt over sand and gravel. This material is so light that the increase in the velocity of the current during flood periods results in a marked lowering of the river bottom, so that the increased volume of water is accommodated by the enlargement of the channel thus obtained as well as by the raising of the flood level. This condition, of course, introduced no little conjecture as to the security of any substructure not founded on bed rock. Another serious matter is the prevalence of ice floes during the spring breakup, which are capable of exerting enormous pressures against any structure interposed in the river channel. The problem then was to develop pile piers that could be made safe against scouring and capable of resisting the ice pressures.

Combination Pile Pier and Ice Breaker.—The manner of accomplishing this may be learned from a study of the detailed drawing of one of the piers as built. The construction consists essentially of a combination of a pile pier supporting the superstructure with a rock-filled ice breaker of timber cribbing protected against scour by willow mattresses and rip-rap. The vertical load imposed on the pier is carried by 70-ft. piles, capped by a grillage of crossed timbers. It was the intention to provide a bridge seat in the form of a concrete slab 3 ft. thick, but this was abandoned in favor of a top grillage of 3 tiers of 12-in. by 12-in. timbers because of lack of sufficient time to place the concrete in position for the steel work before the spring breakup.

Each side of the pile pier is protected by 12-in. by 12-in. timbers bolted to the outside piles, with 3-in. open joints between. These ties are long enough to extend upstream and form the outer walls of the ice breaker, the sides of which extend 49 ft. 6 in. beyond the upstream end of the pier. The ice breaker also has two interior longitudinal walls as well as cross walls spaced 8 ft. center to center. The upstream end is pointed and slopes back at an angle of 30 deg. with the horizontal. The crib was erected on piles driven at the intersections of the longitudinal and cross walls, while other piles driven in groups of five next to the cross walls serve as a measure of resistance against the ice thrust.

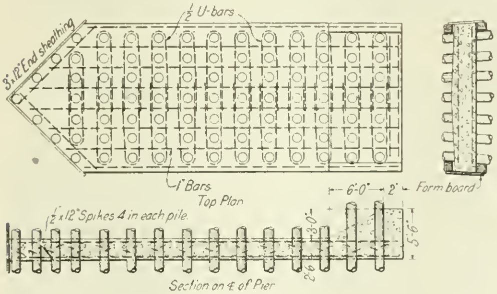
The application of concrete to this construction serves primarily to increase its effectiveness in resisting the ice floes. The most natural development was the provision for a concrete armor over the nose of the crib. This has a minimum thickness of 1 ft. and is reinforced by 1-in. bars placed longitudinally at 1-ft. centers and transversely (horizontally) at 2-ft. intervals in elevation. The edge of the nose is protected by a relayer rail adequately anchored into the concrete. This construction forms a strong, smooth surface to lift and break the ice as it is carried against the pier by the current of the river.

The other concrete feature, while not of as obvious utility, is equally important. This is a horizontal diaphragm or slab of concrete 2 ft. 6 in. thick, covering the entire area of the pier and surrounding the pier piles at a level slightly below high water. The slab increases in thickness at its upstream end so as to present a face 5 ft. 6 in. high against the upstream end of the crib. Thus the slab is designed to receive the thrust of the ice pressure and transmit it uniformly to all the piles in the pier. This slab is supported against sliding down the piles by four ½-in. by 12-in. spikes driven part way into each pile, so that the exposed portions were in the concrete when the slab was cast. Both upper and lower faces of the slab were reinforced with 1-in. bars.

Rip-rap was placed in the crib to fill it to the top, while in the pier the space around the piles was filled with rock to the low water level. As the walls of the pier and crib have their bottoms at about the low water level, or slightly below, the rock spreads out below this level on a natural slope all around the structure. Additional piles driven outside of the pier and ice breaker tend to stabilize the rock slopes thus formed.

To protect the piers against scour the plan called for willow mattresses 150 ft. by 220 ft. in area surrounding each pier and built according to standard methods of mattress construction and sunk by weighing with rock.

Pile Driving Methods.—As the project involved the use of a large number of piles, the pile driving was a major feature of the construction work. The work was started in July, 1918. All piles coming underneath the existing pile trestle were driven by track drivers, one fitted with a No. 1 Union Iron Works steam hammer and the other with a 4,000-lb. drop hammer. All other piles required were driven by a steam hammer mounted on a 40-ft. by 60-ft. power barge that had been used to operate the old pontoon bridge. A water jet was used with each pile. The power boat was also fitted up to supply the water for jetting. A 7-in. by 12-in. by 7-in. steam pump with a 6-in. discharge was installed for this purpose, using 1¼-in. pipes as nozzles for the jets. The driving down-stream from the existing structure was handled readily by controlling the position of the scow with lines from the bridge, but upstream from the bridge the position of the boat had to be maintained by means of an anchor placed in the river about 500 ft. upstream. A 3,000-lb. drop hammer was first employed for this purpose, but it was not heavy enough, and it was reinforced with a concrete block weighing about 4,000 lb.



Details of Reinforcing Slab for the Pier.

Further difficulty was encountered when it came to driving the piles for the north end of the west pier, where a sand bar had formed at a level of 5 ft. above that of the water in the river. To get the scow up to the pier a portion of this sand bar was removed by sand pumps set up on the scow. While the barge was being advanced into the sand bar in this manner, a dike was thrown up behind it, so that when the pumping was finished the scow was entirely surrounded by the sand bar. This protected it from the current of the river, and was also of advantage when it came to placing the lower sheathing for the pier, since it was possible to pump out the water within the bar and place the sheathing with the top 2 ft. below the prevailing stage of water in the river. The piles in the piers were 60 to 75 ft. long and were driven to refusal, some of them reaching bed rock, while others stopped in gravel and boulders after penetrating 30 to 40 ft. of sand and gravel.

Construction Features of Pontoon.—The design for the new structure included a 262-ft. pontoon to replace the original one. The construction of this pontoon formed an important part of the work. This entailed a large amount of heavy woodwork, which was facilitated by the use of power equipment. Much of the framing was done on a band saw, all holes were bored by air tools and bolts were driven with pneumatic hammers. Another feature of the work in which power equipment proved a great labor saver was in the construction of the three longitudinal bulkheads, consisting of 8-in. by 16-in. timbers laid flat and separated ¾ in. by the use of Howe truss packing washers 6 in. in diameter, with rims 3 in. thick. These washers were counter-sunk into the timber, and as there were over 2,000 of them a large amount of special recessing was required. As no tool could be found on the market to cut these recesses a local machinist finally made one from design prepared in the field office which was operated by a Little Giant reversible drill. This was found to work very satisfactorily.

All sheathing was beveled for caulking, and each spike through the bottom and side sheathing was wrapped with oakum before driving. The bottom and sides were caulked with one thread of cotton and two of oakum. The first three threads were hawsed up before the last two threads were driven. The last two threads were placed and caulking strips were extended to cover the seams. The deck of the pontoon was caulked with one thread of cotton and two of oakum and the seams then filled with pitch, 10 per cent of tallow being added to make it more pliable.

Work on the pontoon was started on December 5, 1918, and the pontoon was ready for launching on March 1, 1919, although this did not take place until April 7 on account of low water.

This work was done under the general direction of C. F. Loweth, chief engineer of the Chicago, Milwaukee & St. Paul R. R. The design was under the immediate supervision of H. C. Lotholz, engineer of design, while the construction was under the direction of A. Daniels, district engineer, with the aid of W. E. Duckett, assistant engineer.

1,800 to 2,400-ft. Span Bridge Proposed for Detroit.—An investigation is now underway for a bridge over the Detroit River between Detroit and Windsor, Canada. This work has been placed in the hands of Gustav Lindenthal, as consulting engineer, and Charles Evan Fowler as chief engineer for the joint boards of the American and Canadian companies who will undertake the construction. A great need for a better traffic connection across the river has been felt for many years. Traffic has increased to a great extent and the phenomenal growth of Detroit and the great development of Windsor in an industrial way makes it imperative that modern means of carrying passengers and freight be provided soon. All conditions require the immediate construction of a commodious bridge. The vessels carrying the great traffic of the lakes require an unobstructed waterway, but it is apparent that this can be accomplished in a manner satisfactory to all interests, by a cantilever or suspension bridge of from 1,800 ft. to 2,400 ft. span depending upon the final location adopted. Passenger traffic, automobiles, street cars, auto trucks, and steam trains must be adequately provided for on a double deck structure. While the cost of the bridge will be moderate, its proportions will give it rank among the greatest bridges of the world.

Mohawk Valley Engineers Form Club.—The "Mohawk Valley Engineers' Club" was organized on Jan. 7 by about 125 engineers, architects and chemists. The membership of this club includes civil, chemical, electrical, mechanical, mining, textile, heating and ventilating, automotive and all technical engineers and architects. The club will have regular monthly meetings on the first Tuesday of each month and special meetings intermediate between these at times to be selected. The officers for the first year are: President, Byron E. White, engineer of Utica Gas & Electric Co.; first vice-president, Hubert E. Collins, consulting engineer; second vice-president, Roy F. Hall, division engineer, State Highway Department; third vice-president, Horace B. Sweet, consulting engineer; secretary, Frederick E. Beck, engineer of Consolidated Water Co.; treasurer, Clifford Lewis, Jr., civil engineer. The territory embraced by the activities of the club includes a radius of approximately 40 miles from Utica and it is expected that the membership of the club may reach well above the 200 mark.

New Organization Will Encourage Inventors.—The National Laboratory Foundation for the Development of American Inventions and American Industries has been founded by leading inventors, engineers, financiers and manufacturers of the country. The institutions' purposes are to be "philanthropic in character, to foster, aid and develop the idea and perfect the invention regardless of whether the inventor be rich or poor." It was proposed to found an endowed institution with a complete modern research laboratory, machine shop and research and patent library and with a suitable corps of engineers, chemists and mechanics in charge.

Formula and Curves for Approximating Bridge Costs

Useful suggestions on estimating the cost of steel and concrete highway bridges were given by Mr. Charles D. Snead, bridge engineer, Kentucky Department of Public Roads, in a paper presented Nov. 14 at the Kentucky Highway Engineers' Convention. The matter following is abstracted from the paper.

In approximating the cost of any structure, it is necessary first to know as far as possible all local conditions. This information is secured at the time of making the survey and the more time spent in determining true foundation conditions, availability of local building materials, labor conditions, condition of roads for hauling, cost of teams, storage facilities for supplies, co-operation of the landowners, officials and people in general, is time well spent and will be many times repaid to the company, county or state, both in accuracy of the estimates of costs and in the preparation of the final design. Again, before we can estimate accurately—or for that matter approximately—the cost of a structure, we must have a plan that fits the particular conditions from which to estimate.

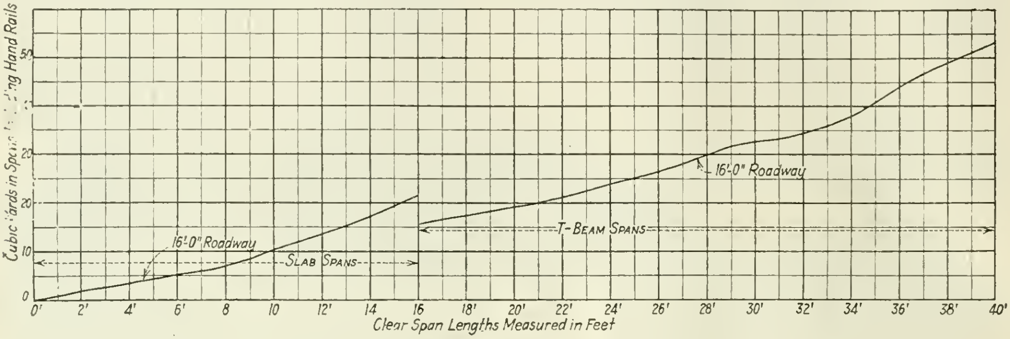
There is one element which enters into bridge construction which is often overlooked and yet is of vital importance. Local parties, desiring to make a small fortune at the expense of the corporation, state or contractor will often raise the price of materials and gouge the public and contractor. This is a large reason why contractors will bid high upon the work and why people oftentimes complain of costs. For example, at the time a survey was made in one locality, 3 ct. per cubic yard would have bought gravel and sand and teams could then be secured for $5 per day. Six weeks afterward the same sand and gravel went up to 50 ct. under the same identical conditions and the cost of teams to $8. These men were the same highly respected, church-going, sanctified citizens who, while professing to be thoroughly interested in public improvement were interested in the improvement only insofar as they could dig into their neighbors' pockets.

Then the people wondered why the estimate was too low and criticised the engineers for being impracticable or theorists.

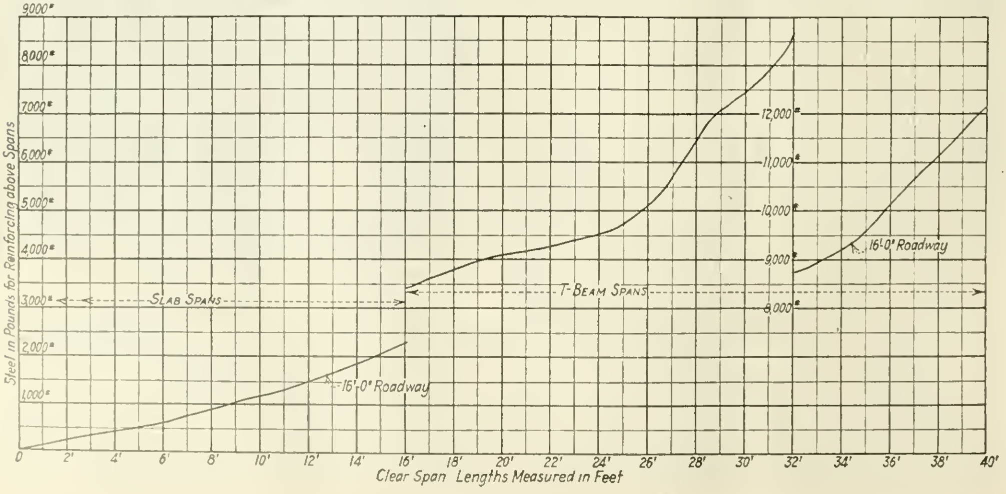
In estimating the cost of a bridge, the unit cost of every item must be carefully approximated. For instance, it is not good judgment to say concrete will cost $15 per cubic yard without basing this figure on local conditions. The cost of cement delivered, the cost of sand, stone or gravel, labor, the cost of form lumber together with a knowledge as to whether this could be again used, the cost of excavation, the cost of finishing and protecting the work and the cost of hauling—all of these must be carefully estimated and finally a reasonable profit must be figured for the contractor. When this is done for all items, then without great discrepancies we should be able to approximate the cost of a structure if we know the quantities involved.

From the accompanying curves we may quickly approximate the yardage and tonnage of steel in concrete spans with 16 ft. clear roadway.

The yardage in plain abutments will be approximately the same for steel and concrete structures (greater for steel structures). This yardage may be approximated roughly by multiplying the height in feet from crown of roadway to the bottom of foundations by the following amounts (tbe yard-



Approximate Amounts of Concrete in Superstructures Only of Reinforced Concrete Spans.



Approximate Amounts of Steel in Slab Spans and in T-Beam Spans.

age including wing walls and represents two abutments for 16 ft. roadway spans):

For abutments up to 10 ft. multiply height by 10.0.

For abutments between 10 ft. and 15 ft. multiply by 14.0.

For abutments 15 ft. to 20 ft. multiply by 15.0.

For abutments 20 ft. to 30 ft. multiply by 19.0.

The yardage in plain piers for 16 ft. roadway spans may be roughly approximated by multiplying the height in feet from top of pier to bottom of foundation by 3.3. These figures will give values far closer than mere guesses.

For steel structures designed to carry a 15-ton tractor and a concrete floor, we may estimate the weights of the structure without sidewalks by Kunz's formula and the added coefficient "X":

$$W = (.12\,L + 12)\ (1.6 - 0.03\,B)\,BLX.$$

In this formula:

W equals weight of steel in pounds.

L equals length of span in feet.

B equals width of roadway in feet.

X equals 1.7 for high riveted trusses (85 ft. to 170 ft.—16 ft. roadway).

X equals 1.43 for high pin connected trusses (140 ft. to 200 ft.—12 ft. and 16 ft. roadway).

X equals 1.67 for high riveted trusses (85 ft. to 170 ft.—12 ft. roadway).

X equals 1.6 for low riveted trusses (40 ft. to 80 ft.—12 ft. and 16 ft. roadway).

Engineering As Prosperity Insurance*

By GEORGE OTIS SMITH,
Director, United States Geological Survey.

Professor Ely, the economist, has boiled down his discussion of the principles of conservation into half a dozen words than can serve as a rule of action: "Civilization means regard for the future." So when I suggest that engineering is prosperity insurance, my choice of words has not been prompted by the professional character of the audience I face, but rather by my idea of what the world needs most.

Fortunately I do not have to define my terms; I have only to set forth the way in which the relation between engineering and prosperity impresses me as paralleling in thought the Ely equation—that civilization means regard for the future. Engineering deals in futures; the engineer ever keeps the factor of safety in mind as he works; he is an insurance agent of the first magnitude even if he does not talk like one.

The research scientist in his untiring quest for eternal truth compels our admiration, but his hard-won truth must be more than seen of men—use is the better mark of possession. It was a chemist who recently summed up the situation thus: "We have science enough now to provide a beautiful, happy, and good world. What shall we do with it?" And my answer tonight is simply—what science has discovered, engineering must apply.

Recently in speaking to representatives of the mining industry, an industry that looms high in the national view as a producer of basic wealth, I said that the dominating note in their policy should be not "wealth" but "welfare." What other word I can bring to you engineers, men who guide the operations and determine the destiny of not alone the mining industry, with all its ramifications in the business world, but of all industry, and who also serve the public directly in that large class of activities that we group together under the term public works.

What we seek for our country, then, is welfare rather than wealth—happiness in fact rather than greatness in name. To strive for well-distributed happiness and to promote the general welfare are aims that belong in the code of the engineer who raises his life work to the level of a contribution to the future.

Prosperity will fail to satisfy us unless it is backed up with guarantees of permanence. Whatever we are to enjoy this year and next we wish our children's children to enjoy in equal if not in larger measure. Can we take out nationwide insurance to cover this forward-looking wish?

My conviction is that the future of our nation will be largely what engineers make it, and the surplus that can be paid to other generations of Americans will depend upon what you engineers of today write into that endowment policy, which is to be broad enough to cover Philadelphia, Pennsylvania, and America.

Conservation of Man Power.—Human energy was something that the ancients spent with little regard for present or future happiness. The great monuments of the past—the engineering wonders of the world—commemorated slave labor. Today we regard manpower as something to be conserved, not only because we as practical business men set a higher value upon humanity than even the philosophers of old, but also because we have learned that in much that we try to do manpower is the limiting factor. In these recent days we have learned to estimate the strength of warring nations in terms of manpower, not simply on the firing line in France, but far behind that line, across sea and land, deep in the copper mines of Montana and Arizona or on the broad wheat fields of the Dakotas and Canada. Everywhere a man saved from unessential work was one more manpower added to the strength of the nation.

To lighten the load of labor is the real purpose in planning for power. In the evolution of industry animal-generated power was first brought to the aid of man, then wind and running water were harnessed, next fuels, through the agency of steam, made possible the modern industrial system, and now electricity has been made a servant of man that promises to lift the burden of toil so that human energy can be put to the highest tasks.

Engineer Must Educate Public in Use of Resources.—Conservation, whether of material or of energy, is engineering, and the policy which a few years ago began to attract public attention is really as old as engineering. The truth is that we needed thrift on a national scale before we began to realize it, and conservation or national thrift therefore became a popular issue. The task is growing larger and more critical, however, as the years pass, and it places a large civic duty upon the engineer. In his role of insurance agent the engineer has not only to plan but to execute, yet in putting his plans into effect he must depend upon popular support. The public must be educated in its use of resources, and the engineer must therefore also function as a teacher.

The engineer may be kept silent by the fear of saying the obvious, of retelling an old story to his fellows. But we too often underestimate the public need for the elementary truths of engineering, and it takes more than one blow of the hammer to fashion public opinion into accord with the facts. Any one who has heard the Great Commoner of today preach political and moral truisms and has seen how he can hold his audience for hours must realize the force that lies in the simple reiteration of well-known truths. It would be well for America if some great engineer with the Bryan power of persuasion could go up and down this country and convince our citizens in their own language of the economic needs of an industry which will produce more than it consumes, of the advantage of large unit operation, of the value to the country of an improved load factor, and of the facts that coal and iron resources represent a nation's expendable assets and that the center of the earth is not an inexhaustible reservoir of oil and gas. These are self-evident truths, but the American people are not yet familiar enough with them—they need to be shown.

Engineer Best Fitted to Tackle Civic Problems.—No type of citizen, then, is better fitted to tackle the civic problems of today than the engineer. The large questions before the people are economic questions, and engineering is mainly science applied to life in an economic way; the engineer in his experience as well as in his training has studied problems in economics, whether his textbook bore that title or not or whether his design or his contract was so labeled or not. The constructive issues that are before the American people this year and that promise to remain before our legislative bodies for several years are all in some degree engineering issues and in a large degree they present on a national scale problems closely akin to those of everyday work that you engineers have in hand on a unit scale. And your strength as citizens comes from the fact that you know that the eternal laws and principles of matter and energy that you must heed in your own working plans must be respected in the nation's policies; no matter how humanistic or idealistic or altruistic such policies may be in motive they will not hold water if they have holes in them.

The transportation problem now before Congress, with

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*Abstract of an address presented Jan. 20 before the Engineers' Club of Philadelphia.

March 1st as the date of delivery for the legislative remedy; the many questions relating to the production and distribution of the commodities that are essential to life and comfort; the working out of the equities of the partnership between labor and capital and the public—these are all practical economic issues to the consideration of which the engineer can bring an analytical mind and a large store of facts.

These public questions are more or less interlocking; our coal problem is hitched up with the railroad problem, and both are related to the superpower plan, while the power program in turn contributes to the labor question, and the underlying ideal of prosperity distribution is but another name for profit sharing, which involves accounting in terms of equities.

Tomorrow's New Type of Prosperity.—The leaders in industry today are calculating the vision of a new type of prosperity tomorrow which must mean profit sharing on a thoroughgoing scale so that all concerned are to receive in proportion as they have served. The goal of wisely directed industry is the prosperous community of happy homes, and engineers must direct such industry.

Yet the engineer must have the full co-operation of the accountant if the returns from industry are to be fairly divided. A true diagnosis of the financial condition of any industry involves bookkeeping that states the real economic symptoms. In mining as in all other productive business, production costs should express all the facts, but I am convinced that we have not yet reached that stage in our accounting methods. The annual reports of our largest mining corporations and the studies by the Federal Trade Commission alike fail to tell the whole story in their statement of production costs, which are made to include the wages of labor but not the wages of capital employed. The Federal Trade Commission in its definition of cost specifically excludes interest on investment, but can we do that in the world of realities? Does not the cost of a pound of copper just as truly include its share of the interest due on the bonds and the dividend due on the capital stock actually paid in—that is, wages paid to capital—as it includes the wages paid to the mine worker or to the man in the smelter? Of course neither pay roll should be padded. Do not regard the definition of profit as a simply academic question for college professors to discuss; it is more a matter of fundamental concern to the men who are trying to build up the industry.

In the first place, such terms as "net earnings," "profit," "net income," "surplus," or "balance to surplus account," which appear on your financial sheets, are too optimistic in tone when the operating costs do not include any charge on account of the investment. The inference is too easily drawn that this surplus is available for profit sharing between labor and capital. For example, the Federal Trade Commission report on copper is quoted in newspaper headlines as showing "28 per cent profit in copper," yet in this report though the wage to labor is set forth as the first and largest item among the elements of cost, this item alone averaging 5 1/3 ct. a pound in 1918, the cost of capital is not included. The report shows, however, that the 85 copper companies discussed would require an average of 3 ct. a pound to pay 10 per cent on their actual investment, yet this 3 ct. does not appear in the 16 ct. of average cost, but instead it forms a part of the 8 ct. so-called "net profit," which the unwary may regard as the actual difference between price and cost.

In the second place, I fear lest accounting which does not count all the costs may lead us to fail to appreciate the results of American engineering. Our engineers, backed up by red-blooded capitalists, are constantly lowering labor costs by increasing the investment in improved mine equipment. This means replacing the hardest part of labor with machinery—it means working dollars instead of men—so that your cost keeping conceals the true state of things if you pay labor out of so-called "costs" and capital out of so-called "profits." By your improvement in equipment you are subtracting from one side of the account and adding to the other, thus ever making the margin apparently larger than it really is. The great strides in advancing our mining industry have come through large investments in plant, and we must in fairness include a living wage for capital as well as for labor when we figure the cost of winning this or that metal from the low-grade ores, metal which a few years ago not all the labor in the world could have won for the use of mankind.

In the January Harper's Magazine a leading press correspondent who is in the closest touch with the events of the day gives to his article on current tendencies in affairs of state the simple title "Political Cowardice." But even where the legislator or executive may be brave, too often he is not well informed. He does not have the point of view of the engineer, whose training in the exact sciences qualifies him to render yeoman service as a citizen. Ibsen, the son of the dramatist, has used an expressive term, "the lag of politics." As you students of mechanics might state it, the mass conditions of statecraft are expressed as inertia, while those of applied science are expressed as momentum; the one is static, the other dynamic. As Ibsen himself states it: "What is called conservatism or maintenance of tradition consists in large part in efforts to lengthen the shadow life of bygone thoughts and orders; it is the past that shall decide for the present; it is the dead that shall rule over the living." The absurdity of the political logic that opposes direct transition to up-to-date conditions is also strikingly exposed by Ibsen. "Suppose," he says, "a little town which has until now got along with oil lamps wishes to introduce electric lights, its water power being easily accessible and cheap, and an official comes along and says that temporarily they must erect gas works, as, historically, lighting by gas is the intermediate step."

Those are some of the reasons why we need to unite in urging the engineers of the country to take a larger share in citizenship; indeed, these are compelling reasons for engineers to assume more of leadership in public opinion.

Santa Monica Pier Failure Due to Permeable Concrete

A commission of engineers recently submitted its report to the City Commission of Santa Monica, Calif., on the conditions and causes of failure of the municipal pier of that city. Recommendations regarding the reconstruction of the pier also were included in the report. The following extracts from the report are reprinted from the Architect and Engineer:

Our examination revealed that while the chemical disintegration of the concrete itself took place, in general, under water, or between high and low tide, the cracking of the concrete along the lines of reinforcement took place almost entirely in the caps and struts and above high water in the piles.

This cracking, as though the result of a wedge-like action at the reinforcing rods, is so general throughout the structure above water that it points to general corrosion of the metal due to one or both of two causes—permeable concrete, as indicated above, or electrolysis.

Although the nature and the degree of the corrosion, and the even yet detectable difference of potential, might furnish slight reason for thinking that electrolysis had something to do with the initial fracture of the concrete, we are of the opinion that the most potent cause of the corrosion was the porous, permeable concrete which allowed the salt sea air to penetrate to the steel.

It is clear from the above that the cause of the present condition of the pier was permeable concrete. This permeability can result from several causes, any or all of which may arise in the absence of the most rigid and competent inspection and careful and conscientious workmanship, or from improper design.

In the light of the present day knowledge, permeable concrete may result from the use either of too much or too little water. Numerous experiments have demonstrated this.

The concrete may be so placed in the forms that there is a separation of materials and consequent alternating dense structure and rock pockets with a large percentage of voids. Forms may be so poorly designed as to be leaky and so allow the loss of the cement, leaving an unfilled mass of aggregate.

Reinforcing steel may be placed too close to the surface to permit of its being adequately covered even with the most dense concrete obtainable.

Forms may be removed so awkwardly and piles may be handled so roughly that the "skin" of lime carbonate is broken and so access is given to the interior concrete for the salt water.

Many if not all of these facts have become known as the result of the experience and experiments of the last few years and were not available to the designers of marine concrete construction a decade ago.

In the light of our present information it is realized that the reinforcement should have been more deeply imbedded, but at the time the pier was designed any engineer would have said it was quite sufficiently covered.

The diary of the inspector records that beach sand and gravel were used in the concrete. This we believe to be an unsafe practice in reinforced concrete construction, for the salt contained therein facilitates the corrosion of the metal reinforcement. Moreover, because of the sorting process of nature in the formation and deposit of beach sand, a very uniform, ungraded product results, which requires the use of an excessive amount of cement to prevent getting a very lean porous mixture. Clean sand and gravel or crushed rock should be used and so graded that, with the cement and a proper amount of water the least volume of concrete will be produced with a given quantity of ingredients. This will produce a dense impermeable concrete.

It should be needless to say that any skimping of the cement required for a properly proportioned mixture would result in a poor and permeable concrete.

In consideration of all of the above facts and observations we believe we are fully justified in concluding that the prime cause of the failure of the pier was the permeable concrete resulting from unskilled and poor workmanship and improper selection and use of materials. A possible contributing cause was the occurrence of two quite severe storms during construction, which cracked many members of the structure, rendering them still more liable to attack by the salt water and air. Electrolysis may have accelerated the corrosion of the reinforcement in the earlier days of the pier, but we do not find evidence of its present operation.

It is possible to repair the present structure by replacing, bent by bent, the concrete substructure in its entirety. Whether this is economically feasible or not may be best determined by considering the probable cost of doing such repair work as compared with wrecking the pier and building an entirely new one.

Advisability of Use of Reinforced Concrete for New Construction.—Before expressing an opinion on this subject, we consider it necessary to state a few facts which have an intimate bearing on it.

Much has been written in later years on the subject of "the action of sea water on concrete," but the consensus of opinion seems to be that reinforced concrete can be made which will successfully resist the action of sea water, but to accomplish this the concrete must be made as dense as it is possible to make it, and protected from serious rupture of its surface where exposed to the direct action of the sea water or salt air.

The quantity and quality of the water used in making the concrete has a most important bearing on the density as well as the strength of the concrete, and on no account should sea sand or sea water be used in its manufacture.

The selection of the materials and the mixing and placing of the concrete must be done under the supervision of a competent engineer, by conscientious and skilled workmen, and with great care.

In the making of a reinforced concrete to be exposed to the action of the sea water and sea air, the personal equation of the employe has an important bearing. A careless or incompetent workman can easily ruin a batch of concrete, and an unscrupulous one would have no hesitation about dumping it in with the other batches, and thus ruin a pile, or other member of the structure. Good materials and unremitting attention to the mixing and laying in the forms, is the price of good concrete for use in sea water.

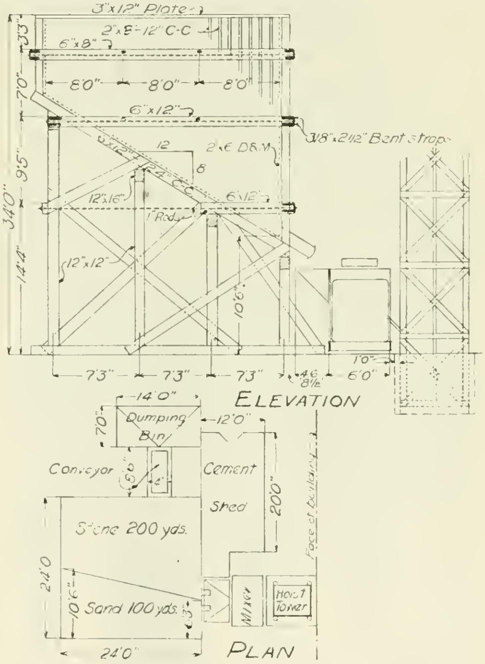
In the case of structures involving the use of long reinforced concrete piles particular care must be taken to avoid any considerable flexure of the piles in handling, or fine hair cracks will be formed which will permit the penetration of salt water to the reinforcement. It has been well established (Hool & Johnson, 1st edition, page 271), that concrete reinforced with steel does not elongate under tensile stress to any greater extent before cracking than plain concrete. This must be taken into consideration in designing piles.

It must be borne in mind that much of our knowledge of the way to make concrete which will resist the action of sea water has been gained since this pier was built, and it is far from our intention to cast reflections on any one in connection with its construction, for we believe that it was well designed and constructed under considerable difficulties. Our only finding is that the materials of the concrete appear to have been not well selected, and not combined in the proper proportion with the proper amount of water to make a sufficiently dense concrete to prevent the sea water from reaching the imbedded steel.

In consideration of the above facts and having in mind the difficulties attending the making of a structure impervious to moisture, particularly in replacing the present piles and other concrete substructure without removing the deck, we are of the opinion that it is inadvisable for the city of Santa Monica to attempt to reconstruct the municipal pier in reinforced concrete.

Aggregate Storage Plant for Winter Work

A compact and efficient aggregate storage plant is employed by R. C. Weiboldt, a Chicago contractor, on his contract for erecting a $450,000 reinforced concrete building at Chicago. During cold weather steam is turned into the steam pipes laid in the bottom of the bin, so the aggregates will be warm when they enter the mixer. The accompanying drawings, reproduced from the January Contractor's Atlas, show the main features of the plant.



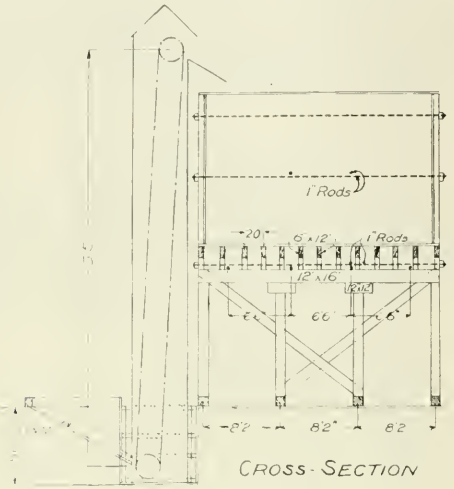
Plan and Elevation of Concrete Plant.

The sand or stone is dumped into the receiving hopper which will take an ordinary truck load. The material is then elevated by means of a bucket conveyor to the top of the bin and flows down a chute into the proper compartment.

The bin is divided into a diagonal partition with the stone compartment next to the conveyor and having a capacity of 200 cu. yd. The sand compartment has a capacity of 100 cu. yd. The material, regulated by means of levers, flows into the mixers and is measured in a hopper between the bin and mixer. The cement is handled in bags and dumped in the hopper in which the stone is measured. In other words, it is dumped right in with the stone as the stone flows from the hopper into the mixer. In cold weather, provision is made for using hot water.

After the material is mixed in the cubic yard mixer it is elevated in a tower and distributed to any point desired by means of chutes. Buggies carry the concrete from the distributing point to the place where it is to be deposited.

The bin is made of 2 in. by 6 in. dressed and matched lumber. The studding consists of 2 in. by 8 in., placed 12 in. on center, which are in turn held by horizontal purlins of 8 in. by 10 in. cross section. Three-quarter inch diameter rods extend through the bin as indicated. The perforated steam pipes of 2 in. cross section are laid on 30 in. centers and are connected to a 6 in. feeder pipe at the upper end. The steam is admitted under pressure of 6 to 8 lb.



Section of Concrete Plant.

Building Operations in 1918, 39% Less Than in Previous Year

Building operations in 1918 in the larger cities of this country showed a decrease of 39 per cent compared with those for 1917 and of 59 per cent compared with 1916, according to a bulletin issued Nov. 4, by the U. S. Geological Survey. The information was obtained from reports from the building department of 143 cities, each showing a population of 35,000 or more.

The following table, from the bulletin, summarizes the operations in the larger cities for the years 1909-1918:

	Number of cities.	Number of permits or buildings.	Cost.	Average cost per permit or building.
1909	137	273,883	$ 930,520,713	$3,398
1910	145	282,661	916,353,775	3,242
1911	145	279,017	863,968,860	3,096
1912	143	278,129	919,809,054	3,307
1913	147	285,850	859,657,250	3,007
1914	147	281,174	785,525,746	2,794
1915	144	292,707	821,120,657	2,805
1916	146	347,761	1,046,276,549	3,009
1917	145	266,686	700,700,815	2,627
1918	143	210,538	430,014,365	2,042

Of the 143 cities 132 reported sufficient detail to permit the publication of statistics of operations by classes of structures. These cities reported 200,786 permits for buildings that cost $372,955,028. Of this amount, new operations of every kind, represented by 81,516 permits or buildings, cost $269,750,562, or 72 per cent of the total; additions, alterations, and repairs, represented by 95,196 permits or buildings, cost $85,699,971, or 23 per cent of the total; and miscellaneous operations, represented by 24,074 permits or buildings, cost $17,504,495, or nearly 5 per cent of the total. In 1917 practically the same cities reported 247,954 permits or buildings, costing $45,980,162, of which 105,018 operations for new work cost $530,416,779, or 82 per cent of the total; additions, alterations, and repairs, represented by 101,094 permits or buildings, cost $92,434,292, or 14 per cent; and 41,842 miscellaneous and undistributed operations cost $23,129,091, or 4 per cent.

The rank of the several cities in the different classes of building operations is relative, not actual, as the expenditures in some cities that reported no details may have exceeded those in some cities that reported the cost of buildings by classes.

Taken by classes, the new wooden buildings in these 132 cities in 1918 cost $89,786,648, or 24 per cent of the total; new brick or hollow tile buildings cost $134,128,524, or 36 per cent of the total; new stone buildings cost $3,840,978, or 1 per cent of the total; new concrete buildings cost $28,299,309, or 8 per cent; and new steel skeleton buildings cost $13,195,103, or nearly 4 per cent. Of the new buildings, those constructed of wood cost 33 per cent of the total for new buildings; new fire-resisting buildings cost $179,963,914, or 67 per cent; those of brick or hollow tile. 50 per cent; those of stone, 1 per cent; those of concrete, nearly 11 per cent; and steel skeleton buildings, 5 per cent.

Of the cost of all additions, alterations, and repairs, $27,428,361, or 32 per cent, was for wooden buildings. Additions, alterations, and repairs to fire-resisting buildings cost $58,271,610, or 68 per cent. Of the fire-resisting buildings, additions to brick or hollow tile buildings cost $48,862,366, or 57 per cent; those to stone buildings cost $2,478,671, or 3 per cent; those to concrete buildings, $3,780,096, or 4 per cent; and those to steel skeleton buildings, $3,150,477, or 4 per cent.

The cost in these cities of all operations on wooden buildings was $117,215,009, or nearly 32 per cent of the total cost of all building operations; brick or hollow tile buildings, new and additions, alterations, and repairs, cost $183,490,890, or nearly 50 per cent; stone buildings $6,319,649, or nearly 2 per cent; concrete buildings $32,079,405, or nearly 9 per cent; and steel skeleton buildings $16,345,580, or 4 per cent of the total.

The decline in the erection of new buildings and the tendency to economize by an increased resort to alterations, additions, and repairs are shown by the following table:

PERCENTAGE OF COST OF DIFFERENT CLASSES OF BUILDING OPERATIONS IN 132 CITIES, 1917 AND 1918.

	1917.	1918.
New construction	82	72
Alterations, additions and repairs	14	23
Miscellaneous, including undistributed operations	4	5

Industrial Notes

The Chain Belt Co., Milwaukee, held its annual convention of Rex Mixer representatives Jan. 18-21 at Milwaukee.

John E. Hubbell, counselor at law and solicitor of patents, formerly of Chambers & Hubbell, Philadelphia, announces that he has opened offices at 469 Fifth avenue, New York, where his practice will be devoted exclusively to patent and trade-mark matters.

J. B. Johnston, formerly manager of the ordinance department, Crucible Steel Co. of America, Harrison, N. J., has been appointed general manager of The Standard Scale & Supply Co., Pittsburgh, Pa., mnufacturers of "The Standard" concrete mixers and other contractors' equipment.

The Sullivan Machinery Co. announces the following appointments by the board of directors: Arthur E. Blackwood, formerly manager at New York City, to be vice-president in charge of finance and accounting; Howard T. Walsh, vice-president, in charge of sales; Gilbert K. Wilson, assistant secretary, in charge of cost accounting; Nathaniel H Blatchford, Jr., assistant treasurer; Emil A. Krevis, general auditor; Frederick W. Copeland, manager foreign sales.

The Buda Co. announces the appointment of R. B. Fisher as general sales manager. He will direct all domestic and foreign sales and advertising departments. Wm. P. Hunt, Jr., will continue as sales manager of the railway department, Mark A. Ross as sales manager of the headlight department, H. L. Miller as sales manager of the frog and switch department, J. L. Artmeier as sales manager of the export department and S. Gordon Hyde as advertising manager. These and other sales departments will be under the direction of Mr. Fisher.

The Sullivan Machinery Co. announces the appointment of Arthur E. Blackwood, hitherto manager of its branch office in New York City, as vice-president, in charge of finance and accounting, with headquarters at Chicago. Louis R. Chadwick, for a number of years manager of the company's office at Spokane, Wash., has been appointed manager at New York City, 30 Church street, succeeding Mr. Blackwood. Robert T. Banks, for several years associated with the company as sales engineer at its El Paso, Tex., office, has been appointed manager at Spokane to succeed Mr. Chadwick.

Obituaries

Prof. Charles Durlin Bray, for 39 years a member of the engineering department of Tufts College, until his retirement in 1908, died Jan. 20 of pneumonia at his home, 98 Professors row, West Somerville. He was 76 years old.

James L. Rake, vice-president and director of the General Asphalt Co., died Jan. 19 in Philadelphia, after an illness of about one week. Mr. Rake has been actively connected with the General Asphalt Co. for over 20 years. He was born in Reading, Pa., Nov. 20, 1856, and resided in that city up to the time of his death, but spent the greater part of his time in Philadelphia, due to his business connections in that city. He was a 32° Mason and a Knight Templar, past grand commander of The Sons of Veterans and national treasurer of that body; past potentate of Rajah Temple, Reading; past secretary of Reading Lodge, B. P. O. E. He was also a director in the Keystone Slag Co. of Reading. Mr. Rake is survived by a widow and two daughters.

Road and Street Monthly Issue

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The four rotated special monthly issues and 4 quarterly issues of E. & C. (52 in all) entirely cover the civil engineering and contracting field at $3.00 a year. The special quarterly issues relate entirely to foreign engineering and construction practice. The *articles* in the first two issues of each month completely cover the municipal engineering and contracting field. The *articles* in the first and fourth issues of each month completely cover county engineering and highway engineering and contracting. The *articles* in the 3rd and 4th issues of each month completely cover steam and electric railway location, design and construction. See the "masthead" on the first page of the Weekly News Section for information about our weekly contract news.

Roads and Streets—1st Wednesday
(a) Roads
(b) Streets
(c) Street Cleaning
(d) Municipal Miscellanies
(e) Management and Office System

Waterworks and Hydraulics—2nd Wednesday
(a) Waterworks
(b) Sewers and Sanitation
(c) Irrigation and Drainage
(d) Power and Pumping
(e) Management and Office System

Railways and Excavation—3rd Wednesday
(a) Excavation and Dredging
(b) Rivers and Canals
(c) Quarries and Pits
(d) Railways, Steam and Electric
(e) Management and Office System

Buildings and Structures—4th Wednesday
(a) Buildings
(b) Bridges
(c) Harbor Structures
(d) Miscellaneous Structures
(e) Properties of Materials
(f) Management and Office System

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Motor Vehicle Operating Cost Essential in Designing Economic Highways

If one company owned and maintained the railway tracks and if another company owned and operated the rolling stock, it is evident that the track would not be maintained by the first company in a manner satisfactory to the second company.

In general, when two or more organizations co-act in effecting a result, without a common directive head having power to co-ordinate their actions, there is invariably failure to secure the maximum of economy.

A striking instance that falls within this generalization is transportation over roads and streets. The public owns and maintains these highways, but it does not own and operate the vehicles that travel over them. To make matters worse, only a part of the public pays directly for the construction and maintenance of the highways, and it often makes those payments under compulsion. Moreover, the civil engineers in charge of highway construction and maintenance have only a limited power to exercise their judgment as to what is most economic. Finally, these engineers lack adequate data both as to the magnitude of the traffic over the highways and as to the detailed expense of operating the motor vehicles under different conditions.

Upon the face of these facts it is clear that there is today no economy in highway transportation comparable with that in railway transportation, nor will there ever be until highway engineers have both the necessary data of transportation costs and the power to act as the heads of railway systems act in co-ordinating all the economic factors.

Consider, for example, the expense of tire renewals where the streets of a city are in poor condition. There are no printed data to show how this expense varies with the condition of the roadway. Similarly, we know nothing as to the extent that maintenance expenses of motor vehicles are affected by the roughness of roadways. And we know relatively little as to the relation between roadway surfaces and the consumption of gasoline per car-mile. Extensive tests should be made to determine these factors, and the inferences from data thus secured should be checked against the operating and maintenance expenses of companies that own motor vehicles.

Probably the manufacturers of motor vehicles could be persuaded to furnish the vehicles and the money needed for tests such as we have suggested. Without doubt, the oil companies, the Bell Telephone Companies, and many other large owners of motor vehicles would not only give access to their operating expenses but

28 Pages=40 pages

The 28 pages of articles in Engineering and Contracting contain as many words as 40 pages of the size and typography commonly used by other engineering periodicals. Ours is the same size of type and type-page as that of The Literary Digest—easily read, yet giving a large volume of reading matter per page. Our 28 pages of articles would fill 112 pages of the standard 6x9 in. text-book. It would take 10 such books of 580 pages each to hold all the articles printed each year in Engineering and Contracting, to say nothing of our weekly construction news.

would undertake so to keep their expense accounts as to disclose any desired facts. In their rural delivery routes, the trucks of the oil companies travel over all kinds of roads. Some of the routes are over well-paved highways, others over unpaved roads. Data gathered as to maintenance, tire renewals and gasoline consumption over each of the different routes in a single state would probably be exceedingly useful to highway engineers. Such data compiled in every state would unquestionably throw a vast deal of light upon this important subject.

In this connection we advise every highway engineer to read and re-read Wellington's "Economic Theory of Railway Location." That great book is about a third of a century old, but a study of Wellington's methods of attacking economic problems is well worth while. It is one of the few engineering books that is inspirational. Study Wellington's careful analysis of railway operating expense and the uses to which he puts the data in designing and locating a railway. His economic methods are applicable in highway design and location. It is true that several of the recent books on highways contain expositions of Wellington's methods, but they all lack the vast array of analyzed operating data that Wellington gives, because such data are not yet available in the highway field. Saturate your mind with Wellington's data and you will realize not only what a dearth of corresponding information exists in the highway field, but what a great handicap this lack of information places upon highway engineers.

What Is the Matter With Palmer's Panacea?

Several months ago Attorney General Palmer told the railroad brotherhoods and other labor unions that if they would be patient the government would so reduce the cost of living that higher wages would not be needed. The brotherhoods have apparently decided that the time limit on their patience has almost expired, and there are signs that even the newspaper editors who have been counseling "patience while Palmer acts" are also losing patience.

We pointed out at the time that Palmer had left entirely out of consideration the most important factor in the high cost of living, namely, the great increase in currency and bank deposits. His panacea involved (1) increased production, (2) decreased spending and (3) "the determined hunting down of profiteers."

This absurd program for the rapid reduction of prices having fallen flat, perhaps attention will now be turned to the fundamental cause of high prices, namely, inflated currency. In previous editorials we pointed out that a general increase of production accompanied by a general decrease in buying would be an economic absurdity. The Manchester "Union" pertinently asks what will happen when the workers have piled up goods which the public, acting upon Palmer's advice, refuse to buy. The Chicago "Tribune" replies that the American public need not buy the surplus, for it is sorely needed in Europe, but it fails to tell us how an almost bankrupt Europe can buy our surplus. Moreover, Herbert Hoover points out that about $150,000,000 is about all that we should lend Europe—merely enough to fend off starvation. What Europe needs is a stabilizing of governments and of money supply, so that its capitalists can safely resume productive enterprises on the pre-war scale. Americans can not help Europe by working more in order that Europeans may continue to work less.

Royal C. Meeker, U. S. Commissioner of Labor Statistics, states that currency inflation is the main cause of high prices. In this view he is supported by Lord d'Abernon, chairman of the Dominion's Royal Trade Commission, who recently said:

> Whereas, in 1913, the total amount of paper money in the principal countries of the world was approximately £1,250,000,000 ($6,250,000,000), the amount in December, 1918, was £6,000,000,000 ($[illegible]000,000,000). This total excludes Russia, Austria and Turkey, who are arch-inflators. It is, therefore, an understatement.
>
> Does it not seem probable, therefore, that the real cause of the high prices which now prevail is not deficiency of production—for we have seen that production has been maintained within 10 per cent of the previous level; but inflation proceeding from the base currency issues throughout the world, which have increased the aggregate amount of paper money in circulation by about 400 per cent.
>
> You will see that where the amount of currency in circulation is highest—as in France and Italy—there prices have risen the most; whereas in the United States, where currency has only increased by 73 per cent compared with 1913, the rise both in wholesale and retail prices has been considerably less than in other belligerent countries. The progression and parallelism are strangely uniform, allowance being made for the influence of world-prices and world-currency conditions on local prices in each country.

In similar vein a circular issued by the American Exchange National Bank states:

> In 1913 the money in circulation in the United States amounted to $3,390,000,000, while bank deposits amounted to $12,678,000,000. Reliable estimates place the circulation in 1919 at $5,709,000,000 and the bank deposits at $25,731,000,000, an increase of 68 per cent since 1913 in circulation and 350 in deposits.
>
> Estimates indicate that the physical volume of trade in 1919 will show an increase over that of 1913 of only 8 per cent. With almost double the amount of money and credit, we are producing at the rate of less than 10 per cent more goods. As this can hardly be regarded as a normal increase, we are forced to conclude that production has actually fallen behind.

The noteworthy fact is that America is actually producing fully 8 per cent more than six years ago. While this is below the normal increase in production, note that it is fully abreast of our increase in population; hence that it is absurd to name decreased production as the main cause of high prices.

The Attorney General, following the habit of men not accustomed to measure causes and effects, has failed to give proper advice to the public. The majority of daily papers, misled by his promises, have similarly misled the public. We may now look for a more critical study of the effect of currency inflation upon prices.

Failure to Employ Engineers Caused Blunder in Estimating Cost of Carrying Second-Class Mail

If an electric power company were to ask a public service commission to raise certain of its power rates 200 per cent, it would be met with a volley of questions, among the first of which would be: Have your costs been recently analyzed by expert rate engineers? If the company were to reply that it had never heard of such engineers, those of us familiar with railway and public utility rate investigations know the sort of answer the company would receive to its request for higher rates. It would be futile for the company to protest that its accountants had analyzed the costs, for public utility commissions would not accept their evidence as conclusive. The commission would demand an investigation by engineers skilled in electric power cost analysis, for it is now well established that scientific cost analysis is an important branch of engineering, and not a mere matter of bookkeeping.

Yet when the Post Office Department went to Congress a few years ago asking an enormous increase in the rates charged for second-class mail, it was in precisely the position of a public utility company asking a public service commission to grant a rate increase. But Congress, being wholly without technical experience in rate matters, did not even demand an up-to-date analysis of the unit costs of mail transportation. Instead it began by assuming that a so-called postal cost investigation made in 1911 must be essentially correct because it was made by a commission of three honorable men. Were those men rate engineers? No. Had they employed rate engineers to solve any of the intricate economic problems of transportation and delivery of the mails? No. Had they, in fact, done anything more than review a lot of statistics compiled by the Post Office Department to prove its case? No.

This commission, headed by Charles E. Hughes, made its so-called investigation of second-class postage costs in 1911, based on postal statistics for 1908. The very age of the data alone would have caused a public service commission to exclude them from consideration in establishing rates for 1918; but Congress saw nothing incongruous in accepting this ancient history not merely as evidence, but as the sole evidence of an impartial nature. However, we do not object so much to the fact that the cost data were nearly ten years old as to the fact that they never were subjected to the critical analysis of a single one of the hundreds of expert rate engineers of America. Practically every state has its public service or railway commission, and almost every commission has its corps of engineers, men trained to appraise property, analyze operating expenses and prorate costs on a scientific basis to different classes of service. These engineers number several hundred. Then there is an even greater number of appraisal and rate engineers in consulting practice and in the employ of the public utility companies and railways. But Congress, in ignorance that there is not merely a science of cost analysis, but a large body of engineering specialists practicing that science, proceeded to decide one of the greatest of rate cases without a scrap of testimony from the only experts competent to give worth while testimony on the cost of mail transportation, namely, appraisal and rate engineers.

Apparently there is very little general understanding of the nature of rate problems. To the uninformed man it evidently seems that any one is competent to analyze costs, provided only he be "quick at figures" and reasonably conversant with the nature of the subject. We can imagine the astonishment with which Congressmen would scan the bibliography of appraisal and rate articles published seven years ago by the American Society of Civil Engineers. They could scarcely believe that a selected list of the best articles numbered more than a thousand titles. Nearly all these articles have been written by engineers. There are a dozen good American books devoted to appraisal and rate matters, all but two of which were written by engineers.

In short, here is a great body of technical literature written by expert rate and appraisal engineers, yet we venture to say that the Congressional committees that decided this very important postal rate case would read with surprise the statements just made. Never once in cross-examinations of witnesses nor in their comments upon testimony did a single Congressman betray the slightest acquaintance with any shred of all this vast literature on rate making. Never once did any one of them show the remotest acquaintance with even the principles of rate making. It was before such a court that one of the greatest rate cases in the world was tried.

The Hughes Commission in 1911 came to the conclusion that in 1908 it was costing the government more than 6 ct. a pound to handle the second-class mail, exclusive of general expense and miscellaneous items not apportioned.

We have carefully studied the report of the Hughes Commission (House of Representatives Document No. 559), and find astonishing errors. A rough analysis of the data leads us to the conclusion that, instead of 6 ct., the cost of handling second-class mail was about 2.5 ct. Many of the errors in the report are traceable to lack of understanding of the theories of apportioning or prorating joint costs. Since nearly all the costs of operating the Post Office Department are joint costs, it is evident that either an erroneous theory of prorating them to the different classes of mail, or an incorrect use of a correct theory might lead to serious mistakes.

If any engineer is interested in ascertaining how greatly a non-technical committee can blunder in its interpretation of statistical data, let him study the above-named report by the Hughes committee. We have never seen greater blunders of this character than are to be found in that report, except those made by the Post Office Department itself in its various reports on the same subject.

Nebraska Road Institute.—The third Nebraska Road Institute will be held March 1-5, inclusive, at the University of Nebraska. All Nebraska engineers, surveyors, draftsmen, highway commissioners, county commissioners or supervisors, road builders, contractors, and other persons interested in the improvement, construction, and maintenance of Nebraska's public roads and bridges are invited to attend. The Institute will be conducted by the College of Engineering of the University of Nebraska with the co-operation of the Nebraska Department of Public Works and a number of prominent Nebraska road builders. The institute was inaugurated in 1918 with an attendance of nearly 200 persons representing nearly every county in the state. Nearly 300 persons attended the institute in 1919. It is expected the attendance of the third institute will be in the neighborhood of 500.

Subgrade for Rigid Pavement

To the Editor: The life of a pavement depends, to a very large degree, upon the character of the base, which in turn depends very largely upon the character of the subgrade. Then it is very plain that the life of the pavement depends largely on the subgrade.

Mr. O. C. White, in your issue of Dec. 3, brings out some interesting points along the line of securing a proper subgrade for pavements. There are two specific points to which the writer desires to call attention. First, in his experience as assistant city engineer at Bartlesville, Okla., he found that where pavements were constructed on streets from which the land sloped down in both directions no drainage precautions were necessary; on streets lying on the side of inclines some attention had to be given to drainage and on streets to which the property sloped in both directions a great deal of drainage precautions were necessary. Second the securing of a uniformly solidified subgrade can be secured by the use of uniform materials and rolling which is so thorough as to identify all soft spots such as recent sewer fills, etc.

The length of time that a new fill should be used before placing thereon a pavement depends not on the element of time, but rather on the elements, traffic and moisture. The writer has observed that good results were secured by the use of crushed stone base placed on a subgrade that was so wet that mud 6 in. deep developed. However, the soil was quite uniform in character and had been thoroughly settled by wet weather. When the crushed stone and brick were placed thereon even before it had entirely dried, the heavy rolling and the attending clearing of the weather left this pavement in A No. 1 shape, as was proved when the street was opened to traffic. This particular piece of pavement was laid in 1914 and is in good shape today, having successfully borne the heavy oil industrial traffic in the meantime.

One noteworthy experience of the writer was also found in Bartlesville in 1918. A concrete pavement was laid on an excavated subgrade in a flat locality. During the hot and dry summers the ground often cracks. This pavement, although laid on a uniformly firm material, cracked badly during its first summer. Are we to assume that the heavy pressure set up in the subgrade and pavement were sufficiently strong to overcome the tensile strength of the latter?

R. E. SPEAR.

Chicago, Ill.

Cost of Road Surveys in Missouri

The new Missouri road law which went into effect last March authorized the designation of 6,000 miles of state road in Missouri and directed the state highway engineer to without delay survey and make plans of this mileage. It fixed the cost of the surveying and plans at not over $100 per mile on the average, the cost to be deducted from the $1,200 a mile, which each county was to receive free on not less than 50 miles of state road. The state highway department promptly placed six state surveying parties in the field, made contracts with private engineering firms and gave permission to counties desiring to do their own surveying for about 2,250 miles of road. By Dec. 1, when freezing weather forced the suspension of work in the field, one-third of the 6,000 miles had been surveyed. Six hundred miles of this work had been done by the state parties. If the present rate of surveying can be continued, all of the authorized mileage will be done by the end of 1920. Surveys have been made in whole or in part of 86 counties. In the remaining 28 counties no start has been made, but work in them will begin as soon as the weather permits in the spring. The surveying by the six state survey parties has been done at an average cost of about $75 a mile, leaving $25 a mile for the completion of the plans. The balance of the surveying by the counties and contracts with private engineering concerns has been done at the price authorized by law and that includes the plans.

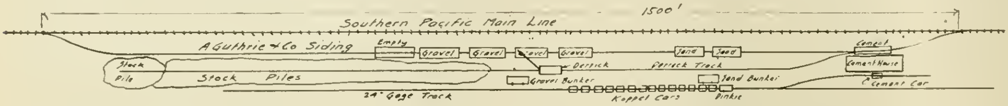
Working Capital Required of Contractors.—Contractors on future awards of state highway work in Wyoming will be required to show to the state highway department that they have a cash working capital of at least 20 per cent of the total contract.

New Type of Mixing Plant Used on 11-Mile Concrete Paving Job in Oregon

By R. F. HOFFMARK,

Western Superintendent A. Guthrie & Co., Inc.

On Feb. 7, 1919, A. Guthrie & Co., Inc., of St. Paul, Minn., and Portland, Ore., was awarded the contract for paving the Hillsboro-Multnomah county line state highway in Washington County, Oregon, for a distance of 11.25 miles. The type of pavement was Oregon state highway specification No. 2, 6-in. concrete pavement, 1:2:3½ mix. Oregon state highway pavements are 16 ft. wide with a 2-ft. gravel or crushed rock shoulder on each side. Items of particular interest in connection with this contract are that the pavement parallels the Southern Pacific Railway tracks for a distance of 8 miles; that the pavement was laid for almost its entire length on a newly-graded road and that it was in the main level with only three short stretches of 5 per cent grade.



Typical Layout for Unloading Sand, Gravel and Cement.

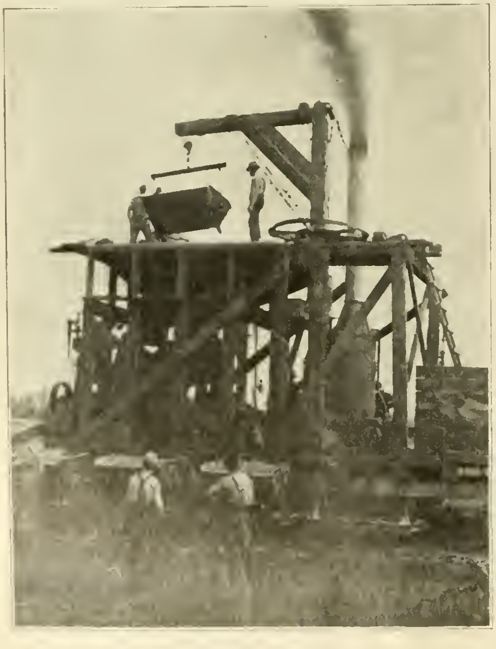
The work was planned and will be described in this article under the following headings

1. Origin and Transportation of Sand, Gravel and Cement.
2. Water Supply.
3. Unloading Spurs and Stock Piles.
4. Preparation of Subgrade.
5. Distribution of Materials to Mixing Plant.
6. Mixing Plant and Crew.
7. Sprinkling, Covering and Shoulder Construction.
8. Camps.
9. Time Schedule and Progress.

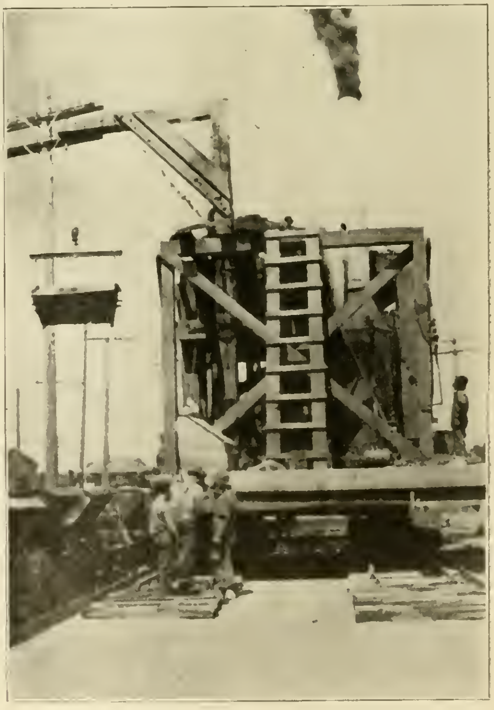
Origin and Transportation of Sand, Gravel and Cement.—In this particular locality sand and gravel must necessarily come from either the Columbia River or Willamette River. Sand and gravel plants to a considerable number are located in and around Portland. After thorough study it was decided that Portland plants would not be feasible due to the transportation difficulties in getting a rapid movement of sand and gravel cars over the different lines switching in Portland city limits. Following this line of thought it was decided to purchase sand and gravel at two plants on the Willamette River which were an average distance of 25 miles from the work. Accordingly these two plants were put under contract and one plant was entirely rebuilt in order to supply the requirements of this work. Sand and gravel shipments were handled the entire distance from plant to job by one railroad, thus simplifying car requirements, delivery and switching service. The Oswego-Portland Company's cement plant is located at Oswego on the S. P. tracks, an average distance of 20 miles from the work. The cement supply was therefore sure. A study was made of the advantages of bulk shipments over sack shipments but owing to the design of the mixing plant contemplated it was decided to adhere to sack shipments.

Water Supply.—An 8-in. wooden main connects the city of Hillsboro with the city of Beaverton, practically paralleling the work for a distance of 8 miles. Arrangements were made for connecting the 2-in. supply line with the 8-in. main at numerous points so that the supply line was never longer than 3,500 ft. Three meters were used for the connections. The water supply on the work was excellent although it was found necessary during the hot summer months to install a booster pump at our main meter in order to have sufficient head for supplying all requirements. For the 3¼ miles where no main was available a gasoline pump was installed in a well sunk in a nearby creek channel.

Unloading Spurs and Stock Piles.—A careful study of



Side View of Mixing Plant.



Mixing Plant Backing Away From Finished Pavement. View Shows Tracks and Excellent Condition of Subgrade.

grades and available places for spurs was made and arrangement perfected with the Southern Pacific Ry. Co. for the installing of turnouts. It was decided to have three unloading spurs on the work, the spurs varying in length according to location. The accompanying switch shows a typical lay-out. It will be noted that in addition to the spur for loads and empties a running track was installed for the clam shell derrick used for unloading purposes. This derrick was thus enabled to move within reach of any car which it was desired to unload. The derrick was a Model 40 Marion steam shovel equipped with a boom and an extra drum. The cement house in each case was so located that the loading of the narrow gage cement cars would not interfere with the loading of the narrow gage sand and gravel cars. The sand and gravel bins into which the clam shell unloaded were of light construction and on skids so that they could be moved about by attaching them to the derrick. They were designed with a capacity just sufficiently large so that one narrow gage train could be loaded with one filling of the bins. Owing to limited space stock piles were not as large as they should have been, the largest stock pile being at unloading spur No. 2 which contained enough sand and gravel for the construction of ¾ mile of pavement.

Half Day's Run of Mixing Plant. Covering Shows End of Previous Day's Run. Note Cement Car Ahead of Dinkey.

Preparation of Subgrade.—The rough grading on this work was done by county forces and the usual kind of equipment was used. In preparing the subgrade for the pavement no unusual methods were developed. A finishing gang, consisting of foreman, six men and a 10-ton roller, kept well in advance of the paving operations. At points where the subgrade had been left from 1 to 3 in. too high a disc harrow, heavily weighted and drawn by a Cleveland tractor, was used for cutting up the stiff material. This proved to be much more satisfactory than ordinary plowing methods used at the start of the work. The usual precautions of preparing well rolled and compacted subgrade were observed.

Distribution of Material to Mixing Plant.—The equipment used for this distribution consisted of the following:

2 24-in. gage 7½-ton steam dinkies.
34 36 cubic foot roller bearing Koppel concrete cars.
4 24-in. gage Petler dump cars converted into flat cars.
12,500 track feet of 20-lb. rail.
4x6 4 wooden ties spaced 2 ft. center to center.
8 20-lb. switches.

This 2-ft. gage track was laid so that the end of the ties just cleared the outside of the form. Passing spurs were put in at intervals of about 2,000 ft. The track was not in built up sections but was laid, taken up and re-laid in the same manner that standard gage railways employ. Two trains were operated continuously during the concreting operations, each train consisting of 15 cars of sand and gravel in the ratio of about 6 gravel to 4 sand and one flat car containing the required number of sacks of cement loaded on a cement cage which was built especially to fit the cement car. Trains were operated at a speed of about 10 miles per hour and were in charge of one engineer and one brakeman. At the loading spurs the brakeman and one assistant operated the gates for charging cars with sand and gravel from the bins. Before proceeding to the sand and gravel bunkers the cement car was kicked into the track leading to the cement house, and while sand and gravel loading was proceeding the cement car was being loaded by men who were unloading main line cars and loading narrow gage cement cars on a contract basis. During the entire summer's operations there were only two engine derailments and probably five car derailments, the time lost to derailments being negligible. Shoulder gravel was hauled out by trains during break downs, shortage of sand, rainy days and during the moving periods.

Mixing Plant and Crew.—The mixing plant was a new departure in paving equipment. The machine was designed and constructed at the company's shops at Vancouver, Wash., with the view of eliminating the shoveling of sand and gravel from the subgrade into the loading skip of the ordinary paving mixer. No new machinery was purchased. Briefly the machine consisted of a 24 cu. ft. dry capacity mixer with engine; a 7x10 American hoising engine and a 2-cylinder reversible crowding engine taken from the boom of the Model 40 Marion which was being used as a clam shell derrick; this crowding engine was used for propelling the entire machine and swinging the mast. This machinery was mounted on a timber platform which rested on four 4-yd. Petler car tracks which operated on two 3-ft. gage tracks inside the forms. The tracks consisted of built up sections of 40-lb. rail, each section being 4 ft. long. These sections rested on 4 x 8 ties giving an excellent distribution of the weight of the machine on the subgrade.

Above the platform storage hoppers were built for sand, gravel and cement of sufficient capacity to pour a 30-ft. slab of road. The Ransome mixer was equipped with a measuring hopper for sand and gravel which was delivered to it from the storage bins above by two ordinary sand and gravel gates. The cement went from the cement bin into a cement measuring box and from the measuring box by means of a specially constructed cement gate into the sand hopper.

As shown in the accompanying illustrations the 7 x 10 hoisting engine operated an L-shaped mast which picked up the bodies of the Koppel cars and hoisted them to the storage bins above where they were dumped into their proper compartments by two top men and then lowered back onto the Koppel car frame. Mixed concrete was deposited on the road by means of 16-ft. spout, a long spout being possible due to the fact that the mixer discharged 8 ft. above subgrade. The machine had 16 live wheels propelled by means of sprockets and chains and negotiated 5 per cent grades without difficulty of any nature. The theoretical traveling speed of the machine was 30 ft. per minute. The move back sections of rails and ties were handled by four men and the machine was backed up in exactly the same manner that a track shovel is moved forward.

The hoisting boiler on 7x10 American engine supplied steam for all three engines, it therefore being possible to run the plant with one fireman. Besides this fireman the crew consisted of one hoisting engineer, one mixer engineer and one man for operating sand and cement gates, the mixer engineer handling the gravel gate. The mixing operation was almost continuous as while one batch was being mixed the measuring hopper was being charged with the next batch from the storage bins above. Because of these storage bins the machine was enabled to continue concreting operations while trains were passing at the nearest siding. The entire mixing and finishing crew consisted of one foreman and 16 men.

Sprinkling, Covering and Shoulder Construction.—These three items were handled in the usual manner except that the men performing the labor were doing so on a contract basis and not by day labor.

Camps.—With the mixing plant as outlined above it was planned to do the entire 11¼ miles with one camp outfit making two moves. It was considered essential to make the moves quickly and an entire camp on wheels was designed. No unusual construction details were developed but it was found that for summer work a wagon camp for road construction was the most economical method of solving the troublesome camp proposition.

Time Schedule and Progress.—A progress chart for the work was platted, it being planned to start concreting the first of June and complete on schedule time, Oct. 31. Owing to several mechanical difficulties in the newly built plant the start was delayed until June 4th, but concreting was completed on Oct. 21, or ten days ahead of schedule. During the summer it was found necessary to double-shift the operation and accordingly 43 double shifts were worked. In all, 132 8-hour shifts were worked, laying a total of 59,404 lin. ft. of 16-ft. pavement, an average of 450 lin. ft. or 800 sq. yd. per day. Of the total length, 53,404 lin. ft. were laid by the machine described in this article, the last 6,000 ft. being laid by the usual method of dumping on the subgrade with trucks and shoveling into the loading skip of a Koehring mixer. The material was truck hauled from Portland on account of the serious car situation. The mixer averaged 333 lin. ft. per shift. The specially designed mixing plant laid 53,400 lin. ft. in 114 shifts, or an average of 468.5 lin. ft. per shift. The high runs for single shift were 633 lin. ft., 630 lin. ft. and 602 lin. ft. The high runs for double shift were 1,135 lin. ft., 1,102 lin. ft. and 1,025 lin. ft. No hourly progress record was kept as such records are very misleading and have no bearing on the final result of the work. After a shift is started it should be counted as a full shift even if concreting stops within an hour, as full shift expense will be incurred. From an economical standpoint the single shift was desirable only because it simplified the material supply problem. The efficiency of the men on the double shift was far greater than expected and the advantage of the single shift on this particular job was due entirely to the fact that it was found impossible, due to car situation, to supply the work with enough material to keep two shifts going at top speed for an extended period of time.

The period between June 4 and Oct. 21 is divided as follows:

20 days' loss—Sundays and holidays.
10 days' loss—Shortage of material.
4 days' loss—Due to boiler trouble.
[illegible] days' loss—Two moves of camp, track and equipment from storage sour No. 1 to No. 2, and from No. 2 to No. 3.
[illegible] days' loss—Rain.

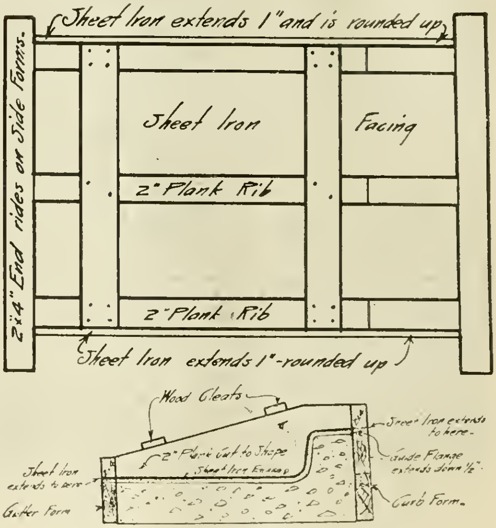
50 days lost out of a total of 139, or 36 per cent.

The greatest difficulty, in keeping up to schedule, experienced on this work was encountered in supplying sand, gravel and cement. This difficulty was not due to the points of origin but due entirely to the scarcity of cars. It was found necessary to employ a traffic man who reported twice daily to the purchasing agent in the Portland office of the company, regarding car movements.

The work was done under the direction of the Oregon State Highway Commission, Herbert Nunn being State Highway Engineer. In direct charge were C. W. Wanzer, District Engineer; C. A. Reiter, Resident Engineer and J. E. Smith, Chief Inspector. Mr. R. W. Smith was Resident Superintendent in charge for A. Guthrie & Co., Inc.

Device for Finishing Concrete Curb and Gutter

A time and labor saving device for finishing combination concrete curb and gutter was employed the past season by Hanlon & Okes, Contractors, Minneapolis, Minn. The accompanying sketches reproduced from the January Contractors' Atlas, show the arrangement. The front and back forms for the combination curb and gutter are set up as usual, the gutter base laid and a portable curb face form clamped in place and the concrete for the curbing tamped in. This face form is then removed and mortar spread roughly over the entire surface of the gutter and curb. The finishing sled, riding on the side forms and guided by a ½-in. metal projection, which is kept snugly against the curb form, is then pushed over the surface, producing a uniform finish that requires no floating and very little troweling.


Sheet Iron extends 1" and is rounded up
2"x4" End rides on Side Forms.
Sheet Iron
Facing
2" Plank Rib
2" Plank Rib
Sheet Iron extends 1"-rounded up
Wood Cleats
Sheet Iron extends to here-
2" Plank Cut to Shape
Sheet Iron Encasing
Guide Flange extends down ½"
Sheet Iron extends to here
Gutter Form
Curb Form.

Curb and Gutter Finishing Sled Used by Hanlon & Okes on Work at Worthington, Minn.

Pennsylvania Highway Department to Have Construction Crews.—The state of Pennsylvania during the 1920 season will have construction crews of its own at work, building important stretches of state highways on the primary system. Not only will the state highway department have its own construction equipment, but it will open its own quarries and sand banks. A new branch has been created which, under the direction of Chief Engineer W. D. Uhler, will have charge of the new activities. The superintendent of this division will be Donald M. Hepburn of Philadelphia.

State Highway Construction in 1919 and 1920.

NEW ENGLAND STATES.

Maine.

HIGHWAY CONSTRUCTION IN 1919.

Type of Roads.	Miles.	Average width surfaced, ft.	Average thickness, in.	Av. cost. per mile.
Gravel	160	16	8	$ 7,500
Bituminous macadam	26	16	6	23,500

PROBABLE CONSTRUCTION IN 1920.

Type of Roads.	Miles.	Expenditure per mile.
Portland cement concrete	40	$35,000
Bituminous macadam	60	30,000
Gravel	210	10,000

AVERAGE UNIT CONTRACT PRICES IN 1919.

Grading, per cu. yd	$ 1.50
Rock, per cu. yd	5.00
Gravel surface, per cu. yd	2.50
Bituminous macadam, 6-in., per sq. yd	1.60
Class A concrete, cu. yd	25.00
Class B concrete, cu. yd	18.00
Reinforcing steel, lb	.06

Paul D. Sargent, Augusta, Me., is chief engineer, State Highway Commission.

Massachusetts.

Appropriations for the 1920 work have not yet been granted by the state legislature. They usually are made during the months of February and March. It is probable, however, that about 100 miles of road will be constructed or reconstructed during the present, and that approximately $5,000,000 will be expended for construction and maintenance.

HIGHWAY CONSTRUCTION COMPLETED IN 1919.

The following table shows the highway work completed last year:

Type of Roads.	Miles.	Average width surfaced, ft.	Average thickness, in.	Av. cost. per mile.
Water bound macadam	1 64	18	6	$12,000
Gravel	26.19	18	6	3,500
Sand and asphalt	3.04	18	4	10,560
Bituminous macadam	40.48	18	6	18,000
Macadam light oil	3.56	18	6	12,500
Bituminous concrete	5.47	18	6	17,000
Cement concrete	6.18	18	7	27,000
Gravel, light oil	7.22	18	6	4,000
Earth	2.10	15	6	2,200

AVERAGE UNIT CONTRACT PRICES IN 1919.

The unit prices in 1919 varied extremely, but a fair average might be consider to be as follows:

Earth work, per cu. yd	$ 1.25
Ledge excavation, per cu. yd	4.00
Broken stone in place, per ton	4.00
Cement concrete surface, per cu. yd	14.00

A. W. Dean is chief engineer, Division of Highways, State Department of Public Works.

Rhode Island.

HIGHWAY CONSTRUCTION IN 1919.

Type of Roads.	Miles.	Average width surfaced, ft.	Average thickness, in.	Av. cost. per mile.
Bit. concrete (conc. base)	1.3	30	8	$61,000*
Bit. concrete (mac. base)	11.7	18	6†	33,000*
Asphalt macadam	10.8	18	6†	32,000*
Concrete	2.2	18	7**	45,000*

*Total costs, including grading, engineering, foundations, drainage, land damages, etc. These items varied greatly.

†Not including foundations.

**6-in. sides: 8-in. center.

PROBABLE CONSTRUCTION IN 1920.

Type of Roads.	Miles.
Bituminous concrete	18.0
Concrete	6.4
Asphalt macadam	13.5

AVERAGE UNIT CONTRACT PRICES IN 1919.

Earth excavation, per cu. yd	$ 1.40
Ledge excavation, per cu. yd	3.75
Stone foundation, per cu. yd	2.50
Concrete pavement, per cu. yd	12.00

I. W. Patterson, Providence, R. I., is chief engineer, State Board of Public Roads.

Connecticut.

It is not possible at present to give details of the proposed work of the state highway commission for the next season. Some of the work which will be constructed in 1920 includes the following. A federal aid improvement about 8 miles long in the towns of Preston, North Stonington, Stonington and Ledyard, involving an expenditure of about $355,000. In the towns of Easton, Redding and Bethel, a contract approximately 12 miles long, involving an expenditure of $315,000. A contract is being advertised (Jan. 20) for the construction of sections of road on the Hartford-New London turnpike, a federal aid project, the total cost of which will be approximately $1,500,000. This improvement will be 32 ft. wide.

In addition to this federal aid work, the state also has awarded contracts for permanent construction as follows: A section of concrete road in the town of Hamden about 5 miles long. A section of concrete road, 22 ft. wide in the towns of Berlin, Wethersfield and Newington on the Berlin turnpike, which is the main highway between Hartford and New Haven. This is about 8 miles long. A section of concrete road in the towns of Thomaston and Watertown approximately 4 miles. A section of concrete road in the town of Thomaston, approximately 8 miles.

AVERAGE UNIT CONTRACT PRICES IN 1919.

Gravel, per sq. yd	$0.66
N. S. macadam, per sq. yd	1.35
Bituminous macadam, per sq. yd	.89
Concrete, per sq. yd	2.60
3-in. bituminous concrete, per sq. yd	2.43
Earth work, per cu. yd	1.50
Rock work, per cu. yd	4.00

Charles J. Bennett, Hartford, Conn., is state highway commissioner.

MIDDLE ATLANTIC STATES.

New York.

On Jan. 1, 1920, the state had approximately 907 miles of highway under contract practically all of which was let during the construction season of 1919.

For the 1920 work, it is hoped to be able to place under contract 775 miles of new construction, 270 miles of reconstruction, 90 miles resurfacing and the surface treatment with oil, 1,000 miles.

Types of construction to be used on this proposed 1920 work will be cement concrete pavement, bituminous macadam, penetration method and bituminous macadam (Topeka specification).

Frederick Stuart Greene, Albany, N. Y., is state highway commissioner.

New Jersey.

The state highway department expects to construct in 1920 between 50 and 75 miles of the state highway system, including work in all sections of the state. This, with the work under way and that part of the 1919 program to be completed early in the spring, will make upward of 200 miles to be completed by the fall of 1920 and will place about 325 miles of the state highways permanently under state control for maintenance and future improvement.

The counties of the state probably will spend during 1920 $4,000,000 or $5,000,000 for new construction in addition to the amount spent for current maintenance. The state will expend on state highway work between $4,000,000 and $5,000,000 for new construction and through the state aid funds to counties, including amounts to be spent by the counties themselves, there will be expended for new construction and maintenance between $8,000,000 and $9,000,000.

The types of pavement will be asphaltic concrete on macadam base, asphaltic concrete on concrete base and concrete pavements.

W. G. Thompson, Trenton, N. J., is state highway engineer.

Pennsylvania.

Some 700 miles of road are now under construction and it is expected that 600 miles additional will be placed under contract before May 1.

W. D. Uhler, Harrisburg, Pa., is chief highway engineer.

Delaware.

HIGHWAY CONSTRUCTION IN 1919.

Type of Roads.	Miles.	Average width surfaced, ft.	Average thickness, in.	Av. cost. per mile.
Brick	5	25	12	$80,000
Cement concrete	32	16	7⅓	37,000

This mileage was actually completed during 1919, 75 per cent of this completed work, was contracted for in 1918.

PROBABLE CONSTRUCTION IN 1920.

Type of Roads.	Miles.	Expenditure.
Cement concrete	95	$4,000,000

This proposed mileage is to be placed under contract, during the season and includes state and state aid work.

AVERAGE UNIT CONTRACT PRICES IN 1919.

Excavation, per cu. yd	$ 1.40
Cement concrete roadway, per cu. yd	14.00

Charles M. Upham, Dover, Del., is chief engineer, State Highway Department.

SOUTH ATLANTIC STATES.

Maryland.

Funds for the 1920 work have not yet been provided by the state legislature. The legislature is now in session, however, and it is expected that it will grant an appropriation at least as large as that of 1919.

HIGHWAY CONSTRUCTION IN 1919.

Type of Roads.	Miles.	Average width surfaced, ft.	Average thickness, in.	Av. cost. per mile.
Plain concrete	101.6	15	7	$33,000
Gravel	26.5	14	8	13,000
Sheet asphalt	9.0	14	3*	12,000

*On existing concrete base.

John N. Mackall, Baltimore, Md., is chief engineer, State Roads Commission.

Virginia.

HIGHWAY CONSTRUCTION IN 1919.

Type of Roads.	Miles.	Average width surfaced, ft.	Average thickness, in.	Av. cost. per mile.
Concrete	50.0	17	6½	$30,000
Bituminous macadam	4.0	16	6	20,000
Waterbound macadam	30.0	14	6	15,000
Gravel	34.0	20	10	10,000
Sand, clay and top soil	38.0	20	10	8,000

PROBABLE CONSTRUCTION IN 1920.

Type of Roads.	Miles.	Expenditure.
Concrete	70.0	$2,500,000
Bituminous macadam	20.0	400,000
Waterbound macadam	50.0	750,000
Gravel	10.0	100,000
Sand, clay and top soil	20.0	160,000
		$3,910,000

AVERAGE UNIT CONTRACT PRICES IN 1919.

Concrete, 6 in., per sq. yd.	$ 2.60
Bituminous macadam, 6 in., per sq. yd	1.60
Waterbound macadam, 6 in., per sq. yd	1.00
Excavation, per cu. yd	50c to 1.50
A concrete, per cu. yd	18.00
B concrete, per cu. yd	15.00
Reinforced steel, per lb	.10

G. P. Coleman, Richmond, Va., is state highway commissioner.

West Virginia.

The state proposes to expend about $5,000,000 in 1920. The work includes 200 miles of hard surfaced roads and 150 miles of grading. This sum will be raised by direct road levies, county bond issues, state and federal aid.

C. P. Forney, Charleston, W. Va., is chairman, State Road Commission.

North Carolina.

A $50,000,000 bond issue is under consideration for a special session of the legislature, probably during the summer of 1920.

The construction carried out last year under the direction of the State Highway Commission included 109.7 miles of hard surfaced roads having an average thickness of surface of 7 in., and 233.3 miles of gravel roads.

For 1920 it is expected the State Highway Commission will construct 92.8 miles of hard surfaced roads and 748.5 miles of gravel roads.

W. S. Fallis, Raleigh, N. C., is state highway engineer.

South Carolina.

About 180 miles of road were constructed in 1919 at a cost of $2,000,000. For 1920 it is proposed to build 400 miles of highway at a cost of $5,000,000.

F. H. Murray, Columbia, S. C., is acting state highway engineer.

Georgia.

The State Highway Department has under construction or under contract for 1919 approximately:

578 miles sand-clay road, average width of surfacing of 16 ft. average thickness about 8 in. and average cost of $2,000 per mile, this including only the surfacing.

In addition there are 37.5 miles of plain concrete paving 16 ft. average width and 6½ in. average thickness costing, including grading, etc., about $35,000 per mile. Also 19.0 miles of bituminous macadam averaging 18 ft. in width and an average thickness of 3-in. surfacing and 6-in base course. This cost on an average of $26,500 per mile including everything necessary for construction.

For 1920 the federal aid work will be continued, and the state expects to build paved roads as far as possible from the income from automobile license tags. This will be about $2,000,000. The federal aid allowed Georgia is about $2,700,000, and this is met by county funds so in the neighborbood of $7,000,000 will be available for expenditure this year.

The average unit prices for the principal items of construction unit prices for 1919, are as follows:

Top soil, per cu. yd	$ .55
Concrete, per sq. yd	2.70
Bituminous macadam, per sq. yd	2.25
Reinforcing steel, per lb	.06
Machine grading, per mile	300.00
Rubble masonry (dry), per cu. yd	3.60
(Cement) masonry, per cu. yd	9.04
Common excavation, per cu. yd	.42
Borrow excavation, per cu. yd	.96
Rock excavation, per cu. yd	1.50
Dry excavation, per cu. yd	1.59
Wet excavation, per cu. yd	3.55
12-in. D. S. V. C. pipe, per lin. ft., in place	.71
15-in. D. S. V. C. pine, per lin. ft	1.25
18-in. D. S. V. C. pipe, per lin. ft	1.58
20-in. D. S. V. C. pipe, per lin. ft	2.62
30-in. D. S. V. C. pipe, per lin. ft	3.85
Class "A" concrete, per cu. yd	23.70
Class "B" concrete, per cu. yd	22.00
Class "C" concrete, per cu. yd	15.63
Class "B" concrete in head walls, per cu. yd	13.26
Clearing and grubbing, per acre	85.00

W. R. Neel, Atlanta, Ga., is state highway engineer.

Florida.

Approximately $3,500,000 will be available for federal aid, state and county sources. The State Road Department, Tallahasee, Fla., proposes to construct 200 miles of state roads, two-thirds of which will be brick and cement, and the rest sand-clay and shell. The counties also propose to expend about $4,000,000 on county projects.

EAST NORTH CENTRAL STATES.

Ohio.

About $25,000,000 will be available for work this year. It is planned to let contracts for about 700 miles of road.

H. D. Bruning, Columbus, O., is chief highway engineer.

Indiana.

HIGHWAY CONSTRUCTION IN 1919.

Type of Roads.	Miles.	Average width surfaced, ft.	Average thickness, in.	Av. cost. per mile.
Concrete	122.08	..	7	$35,000
Bituminous concrete	12	18	8½	40,000

Unless more funds are appropriated no additional work will be let this year.

AVERAGE UNIT CONTRACT PRICES IN 1919.

Item.	Av. bid.	No. of bids av.
Excavation	0.938	71
4-in. concrete base	1.33	8
6-in. concrete base	1.85	19
Concrete pavement (6 in. x 8 in.)	2.82	58
Bit. concrete surface (1½ in. and 1 in. binder)	1.85	19
Vit. block surface	2.69	8
1:2:4 concrete (Class "A") in structures	24.90	71
1:2:4 concrete (Class "A") in head walls	21.65	55
1:2½:5 concrete (Class "B") in foundations	21.60	44
Reinforced steel	0.076	55

H. K. Bishop, Indianapolis, Ind., is chief engineer, State Highway Commission.

Illinois.

HIGHWAY CONSTRUCTION IN 1919.

Type of Roads.	Miles.	Average width surfaced, ft.	Average thickness, in.	Av. cost. per mile.
Portland cement concrete	595	16	7.67	$30,000
Mono. brick concrete hase	22	16	8.5	36,000
Bit. conc. P. C. conc. base	8	18	9.67	40,000
*Plain earth	122	26-30	....	10,000†
Oiled earth	21	15	....	3,900
Gravel	7	10 & 15	9	10,800

*Including drainage structures.
†Average cost ranged from $2,700 to $20,000.

For 1920 plans are being prepared for approximately 1,000 miles of roads on the state bond issue system. Alternate bids will be asked on portland cement concrete, monolithic brick on a portland cement concrete foundation and bituminous concrete on a portland cement foundation. The average width of these roads will be 18 ft. and the 1,000 miles will be distributed throughout the state.

AVERAGE UNIT CONTRACT PRICES IN 1919.

Excavation in earth, per cu. yd	$ .80
Excavation in rock, per cu. yd	3.90
Concrete in structures (exclusive of cement and reinforced steel), per cu. yd	22.50
Portland cement pavement (exclusive of cement), per sq. yd..	1.87
Monolithic brick pavement on a portland cement concrete base (1 in. brick), exclusive of cement, per sq. yd	3.39
Bituminous concrete pavement on a portland cement concrete base (with binder course and exclusive of cement), per sq. yd.)	2.60

Clifford Older, Springfield, Ill., is chief highway engineer, Division of Highways, State Department of Public Works and Buildings.

Michigan.

Approximately $8,750,000 will be available for road construction in 1920. Of this amount $5,000,000 is from the state bond issue; $2,500,000 is a budget appropriation and $1,250,000 is federal aid. It is expected that about 950 miles of state aid roads will be built. There are 516 miles of road under construction at the present time, most of which will be completed in 1920.

Frank F. Rogers, Lansing, Mich., is state highway commissioner.

Wisconsin.

Approximately $18,000,000 will be available from state aid, federal aid and from bond issues. In addition $2,000,000 will be available for maintenance of state trunk highways, and several millions for construction controlled by counties and towns. The $18,000,000 would be expended for the following:

	Miles.
Cement concrete	400
Crushed gravel	300
Macadam	100
Grading	200

A. R. Hirst, Madison, Wis., is state highway engineer.

EAST SOUTH CENTRAL STATES.

Kentucky.

If the state legislature takes favorable action about 250 miles of brick, concrete and bituminous macadam roads may be built at a cost of about $7,000,000.

William N. Bosler, Frankfort, Ky., is state highway engineer.

Tennessee.

HIGHWAY CONSTRUCTION IN 1919.

Type of Roads.	Miles.	Average width surfaced, ft.	Average thickness, in.	Av. cost. per mile.
Waterbound macadam	92.86	16	8½	$15,400
Bituminous macadam	16.35	16	8	22,100
Bit. macadam surface	2.5	23	3	8,800
Concrete*	1.87	16	6	29,300
Concrete	2.5	24	6	35,200

*Does not include grading.

Of the above work totaling approximately $1,960,000 only about 18 per cent had been disbursed for estimates at the close of the year 1919.

PROBABLE CONSTRUCTION IN 1920.

Types of Roads.	Miles.	Expenditure.
Bituminous macadam	230.8	$5,770,000
Waterbound macadam	191.54	2,873,100
One course concrete	25.0	875,000
Totals	447.34	$9,518,100

The above work covers contemplated work in 30 counties and it is planned to let this work to contract in the early spring of this year.

AVERAGE UNIT CONTRACT PRICES IN 1919.

Common excavation, per cu. yd	$ .43
Solid rock excavation, per cu. yd	1.50
Borrow excavation, per cu. yd	.40
Broken stone base course 6 in. thick, per sq. yd	.50
Broken stone surface course 2½ in. thick, per sq. yd	.28
Special concrete, per cu. yd	22.90
Class "A" concrete, per cu. yd	17.70
Class "B" concrete, per cu. yd	17.50
Plain structural steel, per lb	.09
Deformed steel bars, per lb	.06½
Class "A" concrete in bridges, per cu. yd	20.50
Class "B" concrete in bridges, per cu. yd	19.50
12-in. corr. metal pipe, per lin ft	1.45
15-in. corr. metal pipe, per lin. ft	1.90
18-in. corr. metal pipe, per lin. ft	2.20
24-in. corr. metal pipe, per lin. ft	3.27
30-in. corr. metal pipe, per lin. ft	4.50
12-in. concrete culvert pipe, per lin. ft	1.45
15-in. concrete culvert pipe, per lin. ft	1.85
18-in. concrete culvert pipe, per lin. ft	2.72
24-in. concrete culvert pipe, per lin. ft	3.72
Wooden guard railing, per lin. ft	.75

The above figures are the average unit prices for the principal items of construction on five federal aid projects placed under contract in 1919.

W. P. Moore, Nashville, Tenn., is chief engineer, State Highway Department.

Alabama.

The citizens of this state vote on Feb. 16 on a $25,000,000 road bond issue. If the issue carries it is planned to expend $4,000,000 this year for roads.

W. S. Keller, Montgomery, Ala., is state highway engineer.

Mississippi.

About $20,000,000 is available for work in 1920, including $5,000,000 of federal aid. A $25,000,00 state bond issue also is contemplated.

Xavier A. Kramer, Jackson, Miss., is state highway engineer.

WEST NORTH CENTRAL STATES.

Minnesota.

HIGHWAY CONSTRUCTION IN 1919.

Type of Roads.	Miles.	Average width surfaced, ft.	Average thickness, in.	Av. cost. per mile.
Graded	1,100	..	..	$ 3,000
Gravel surfaced	700	20	4	2,500
Cement concrete surfacing	15	18	7	22,500
Asphaltic conc. on conc. base	9	20	3*	34,000

*Not including 6-in. concrete base.

PROBABLE CONSTRUCTION IN 1920.

Type of Roads.	Miles.	Expenditure.
Cement concrete, asphalt concrete or brick	250	$7,500,000
Gravel surfaced	1,500	9,000,000
Graded	300	900,000
Bridges and culverts		1,400,000

C. M. Babcock, St. Paul, Minn., is state highway commissioner.

Iowa.

The probable construction program for 1920 is as follows:

	Miles.
Pavement	356
Gravel surfacing	231
Earth road construction	1,334

In addition about 1,000 miles of graveling will be done by the counties with county funds. Considerable earth road construction also will be done by the counties and townships. About $30,000,000 will be available.

Fred R. White, Ames, Ia., is chief engineer.

Missouri.

The end of 1919 found Missouri enjoying the greatest road building movement in her history. Counties and road districts had voted $18,112,000 in bonds for the construction of state roads in each county with state and federal aid. In addition it is expected that elections will be held early this year to vote on bond issues totaling over $15,000,000. As a result of the bond activity, the state highway board had approved applications for 734.67 miles of hard surfaced road, which, when completed, will cost a total of $10,226,646. Of this mileage 49 projects with a total of 459.29 miles, and a total estimated cost of construction of $5,948,910 have been approved by the federal government.

The new state law which went into effect March 17, 1919, authorizes the building of not less than 50 miles of state road in each county, which shall connect with the state roads in adjoining counties. On this mileage each county receives $1,200 a mile free, provided the county pays for the surveying, which is fixed by law at not over $100 a mile. Half the cost of building a durable road above $1,200 a mile is borne by the state and federal government, and half by the county.

The law guarantees that each county shall receive not less than $60,000 in state and federal aid on 50 miles of state road, but if a county can not build a durable road that will take care of local traffic and preserve the original investment with $1,200 a mile, and the county refuses to finance the cost above $1,200, the state highway department is authorized to cut the mileage and build as many miles of durable road as possible with the $60,000.

During 1917, 1918 and 1919 Missouri completed 480 miles of road with state, federal and county aid. Of this mileage 90.8 was of gravel, 25.6 of macadam, 7.9 of chat, 7.8 of bituminous macadam, 2 of asphaltic concrete, 2.7 of warrenite, 6.5 of concrete and 336.7 of graded earth. The earth road was constructed prior to the passage of the new law. The total cost of this work, which includes bridges and culverts, was $1,106,600.

Many contracts have been let and many more will be let shortly, the work to start this spring, for the construction of the projects approved under the new road law. Work is now under way on 97.25 miles of road and ready to begin on 21.72 miles more when the weather permits, distributed as follows: 7.65 miles of gravel and macadam in Callaway County; 13.5 miles of concrete in Jasper County; 3 miles of bituminous macadam in Boone County; 6.5 miles of chats in Vernon County; 26 miles of gravel in Cole County; 15.5 miles of concrete in Mississippi county; 27.5 miles of gravel in Scott County; 2.2 miles of asphaltic concrete in Buchanan County; 19 miles of concrete in New Madrid County; 5.3 miles of bituminous macadam in Pettis County; 13.07 miles of bituminous macadam in Clay County; 1.75 miles of brick in Randolph County and 1.6 miles of bituminous macadam in St.

Charles County. The total estimated cost for the construction of this mileage is placed at $1,108,824.71.

More miles of state and federal aid roads would have been under construction during 1919 if contractors had bid more freely upon advertised projects. The new road law requires competitive bidding, and when no bids are received within the estimate, the state highway department is authorized to complete the project by private contract, force account or otherwise.

Failing to receive any bids, the department was forced to enter into a contract with the state prison board for the building of 7.65 miles of gravel and macadam in Callaway County with convict labor, and the scarcity of contractors and the great number of projects to be let this year will force the department to build other roads with convicts. About the only projects which attract road building contractors call for expensive concrete, brick and macadam roads. Counties preparing to build the less expensive roads will be forced to organize local contracting concerns, and that is now being done in many counties, in order to build this year the many roads that have been approved.

The roads to be built in Missouri this year with state and federal aid will be almost entirely of a hard surfaced type. Of this mileage embraced in the applications that have been approved by the state highway board, contracts for the construction of which this year will be let shortly, 475.16 miles are to be of gravel to be constructed at a total estimated cost of $3,299,147; 100.95 miles of concrete at $3,461,452; 80.144 of bituminous macadam at $1,959,263; 8.241 miles of macadam at $62,043; 19 miles of water bound macadam at $170,869; 8 miles of asphalt at $142,053; 6.54 miles of Joplin chats at $41,514; 19.42 miles of brick at $847,338; 17.22 miles of graded earth at $242,973.

Alexander W. Graham, Jefferson City, Mo., is state highway engineer.

North Dakota.

The state highway commission has secured or is securing from the U. S. Department of Agriculture formal agreement setting aside federal aid for 39 projects comprising 499.70 miles, to cost $1,452,077. A part of the 499.70 miles has been completed, the rest should be completed early next summer.

Project statements, applications for federal aid, have been submitted to the Secretary of Agriculture for 66 other projects covering 819.48 miles, to cost in the neighborhood of $3,725,779.

The following tables show the mileage of highways constructed in 1919, and the probable construction for 1920:

HIGHWAY CONSTRUCTION IN 1919.

Type of Roads.	Miles.	Average width surfaced, ft.	Average thickness, in.	Av. cost. per mile.
Gravel	40	16	6	$ 6,500
Earth	459	..	..	2,850

PROBABLE CONSTRUCTION IN 1920.

Type of Roads.	Miles.	Expenditure.
Concrete	2	$ 105,500
Gravel	105	540,000
Earth	713	2,392,000

W. H. Robinson, Bismarck, N. Dak., is chief engineer of the State Highway Commission.

South Dakota.

About $10,000,000 will be available for this year. Of this amount $5,000,000 is for federal aid projects, $3,000,000 is county funds for county roads, and $2,000,000 is for bridge construction. It is planned to call for bids this month on work to cost about $1,000,000. Most of the federal aid work calls for a 24-ft. wide gravel road.

Frank S. Peck, Pierre, S. Dak., is state highway engineer.

Nebraska.

Federal and state aid projects totaling 845 miles and estimated to cost $3,252,400 were under contract in 1919. Similar work for 1920 totals 905 miles, estimated to cost $3,879,300.

Geo. E. Johnson, Lincoln, Neb., is secretary, Department of Public Works.

Kansas.

HIGHWAY CONSTRUCTION IN 1919.

Type of Roads.	Miles.	Average width surfaced, ft.	Average thickness, in.	Av. cost. per mile.
Brick	54	18	7 3/16x9 3 16	$45,250
Concrete	67	18	6x8	36,400
Gravel	23	18	6x8	12,800
Macadam	10	18	6x8	18,500

AVERAGE UNIT CONTRACT PRICES IN 1919.

	Low.	High.
Class "A" concrete, per cu. yd	$16.00	$35.00
Class "C" concrete, per cu. yd	12.80	24.00
Hand rail concrete, per cu. yd	20.00	70.00
Reinforced steel, per lb	.045	.10
Brick pavement, per sq. yd	3.00	4.30
Concrete pavement, per sq. yd	2.23	3.10
Macadam pavement, per sq. yd	1.63	2.96
Gravel pavement, per sq. yd	.87	1.05
Excavation (earth), per sq. yd	.35	1.51
Excavation (rock), dry, per sq. yd	1.50	2.50
Excavation (rock), wet, per sq. yd	4.00	13.00
Borrow, per sq. yd	.35	1.23

KANSAS FEDERAL AID PROGRAM FOR 1920.

Federal aid allotted to Kansas will cover only about one-fourth of the mileage now under petition. The state highway commission now has on file petitions for 1,700 miles of surfaced highways and of this mileage, federal aid is now available for the construction of 615 miles, of which 154 miles are now under contract for the following types of pavement:

Brick	54 miles
Concrete	67 miles
Macadam	10 miles
Gravel	23 miles

Twenty-five miles of the above contracts are completed.

This leaves a balance of 462 miles of road to come up for contract as rapidly as plans are prepared. It is anticipated that most of this work will be under contract by July 1, 1920 and thus absorb the $8,000,000 federal aid, which has been allotted to this state.

The following is a list of counties, mileage and probable type which comprises the 462 miles yet to be contracted:

Allen—4 miles brick, concrete or macadam.
Anderson—7.5 miles gravel.
Atchison—10 miles brick or concrete.
Barton—22 miles concrete.
Bourbon—16 miles bituminous macadam.
Chase—4 miles brick or concrete.
Cherokee—10 miles concrete.
Cloud—7 miles concrete or gravel.
Crawford—17 miles brick, concrete or bituminous macadam.
Dickinson—21 miles brick or concrete.
Doniphan—6 miles brick or concrete.
Douglas—32 miles concrete.
Finney—28 miles brick, concrete or gravel.
Ford—28 miles brick.
Franklin—0.8 miles brick or concrete.
Gray—6 miles gravel.
Greenwood—6 miles concrete or bituminous macadam.
Hamilton—8 miles gravel.
Jackson—6 miles brick, concrete or bituminous macadam.
Jefferson—6 miles brick, concrete or bituminous macadam.
Johnson—6 miles resurface bituminous macadam.
Kearney—8 miles gravel.
Labette—6 miles gravel.
Leavenworth—17 miles concrete.
Linn—6 miles waterbound macadam.
Lyon—15.5 miles brick or concrete.
Marshall—10 miles concrete or macadam.
Meade—6 miles earth.
Miami—9 miles bituminous macadam.
Mitchell—7 miles concrete.
Montgomery—12 miles macadam or gravel.
Morris—8 miles bituminous macadam.
Neosho—12 miles gravel.
Ottawa—5 miles brick or concrete.
Reno—15 miles brick.
Rice—4.5 miles brick or concrete.
Saline—12 miles concrete or bituminous macadam.
Sedgwick—4.5 miles concrete or bituminous macadam.
Shawnee—14 miles brick, concrete or macadam.
Sumner—3.5 miles brick or concrete.
Wilson—26 miles gravel.
Wyandotte—9 miles concrete.

M. W. Watson, Topeka, Kan., is state highway engineer.

WEST SOUTH CENTRAL STATES.

Arkansas.

HIGHWAY CONSTRUCTION IN 1919.

Type of Roads.	Miles.	Average width surfaced, ft.	Average thickness, in	Av. cost. per mile.
Asphaltic concrete on concrete base	26	15	7*	$35,000
Penetration macadam	24	14	7	18,000
Waterbound macadam	23	12	7	12,000
Gravel	212	12	7	10,000

*2-in. + 5-in. concrete base.

PROBABLE CONSTRUCTION IN 1920.

Type of Roads.	Miles.	Expenditure.
Asphaltic concrete on stone or concrete base	40	$1,400,000
Penetration macadam	42	756,000
Waterbound macadam	45	900,000
Gravel	373	3,730,000

The above figures should be regarded as approximate, since it is very difficult to separate the work upon a yearly basis, the contracts being let by local improvement districts and covering from 1 to 5 years' work. The state highway department does not have charge of construction and therefore must depend upon district engineers for some of the information.

The estimate of proposed construction in 1920 is for completed work only and the actual expenditure will no doubt be double the amount shown, as much grading and many drainage structures will be built and paid for, thus increasing the estimates given.

Earth excavation, per cu. yd.	$ .47
Hauling and placing gravel, per cu. yd.	1.35
Each additional mile, per cu. yd.	.50
Clearing and grubbing, per acre	175.00
Plain concrete, per cu. yd.	23.00
Reinforced concrete, per cu. yd.	30.00
Penetration macadam, 2½-in. top, per sq. yd.	1.15
Asphaltic concrete top, 2-in. top, per sq. yd.	1.50

V. P. Knott, Little Rock, Ark., is state highway engineer.

Oklahoma.

HIGHWAY CONSTRUCTION IN 1919.

Type of Roads.	Miles.	Average width surfaced, ft.	Average thickness, in.	Av. cost. per mile.
Concrete	8	18	7	$27,000
Macadam	5	16	8	16,000
Bituminous macadam	4	18	5 & 2	26,000
Gravel	22	18	7	11,000

PROBABLE CONSTRUCTION IN 1920.

Type of Roads.	Miles.	Expenditure.
Concrete	50	$38,000
Bituminous	70	35,000
Gravel	180	12,000

Max L. Cunningham, Oklahoma City, Okla., is state highway engineer.

Texas.

Some 200 federal aid projects in 95 counties, aggregating 2,144 miles are under construction or in course of preparation for letting. The estimated cost of these projects is $21,600,000, and they include 87 miles of concrete, 262 miles of bituminous pavement and 1,795 miles of gravel or macadam.

During 1919 counties voted $80,000,000 of road bonds.

Rollin J. Windrow, Austin, Tex., is state highway engineer.

MOUNTAIN STATES.

Montana.

HIGHWAY CONSTRUCTION IN 1919.

Type of Roads.	Miles.	Average width surfaced, ft.	Average thickness, in.	Av. cost per mile.
Earth	6.13	..	..	$ 3,085
Gravel	81.4	12	7	4,442

PROBABLE CONSTRUCTION IN 1920.

Type of Roads.	Miles.	Expenditure.
Earth	650	$1,355,000
Gravel	850	3,472,000
Paving	47	1,425,000

AVERAGE UNIT CONTRACT PRICES IN 1919.

Common excavation, per cu. yd.	30-50 ct.
Rock excavation, per cu. yd.	$2.00
Corrugated metal culverts, per lin. ft.—	
12-in.	1.60
15-in.	2.00
18-in.	2.75
24-in.	3.90
30-in.	5.00
36-in.	6.00
Concrete—	
Class A	27.50
Class B	22.00
Class C	20.00
Reinforcement, per lb.	8-10 ct.
Gravel surfacing, per sq. yd.	32-40 ct.
Grader work	.30
Piling	1.00
Lumber, per M	50.00

John N. Edy, Helena, Mont., is chief engineer, State Highway Commission.

Idaho.

HIGHWAY CONSTRUCTION IN 1919.*

Type of Roads.	Miles.	Average width surfaced, ft.	Average thickness, in.	Av. cost. per mile.
Grading	64.5	..	..	$11,100
Gravel	96.1	16	8	9,500
Crushed rock (surfac'g only)	6.4	16	8	4,250
Bituminous	3.6	18	6	27,750

*Roads constructed and contracts awarded.

PROBABLE CONSTRUCTION IN 1920.†

Type of Roads.	Miles.	Expenditure.
Gravel	148.6	....
Crushed rock	77.7	....
Hard surface	13.0	....
Concrete	7.5	....
Bituminous	37.8	....
Concrete bituminous	6.0	....
	290.6	$1,500,000

†For period ending June 30, 1920.

AVERAGE UNIT CONTRACT PRICES IN 1919.

Clearing, per acre	$100.00
Excavation, common	.55
Excavation, solid rock	2.00
Overhaul, cu. yd. per 100 ft.	.04
Gravel surfacing, per cu. yd.	1.25
Crushed rock surfacing, per cu. yd.	2.25
Concrete, per cu. yd.	25.00
Steel, per lb.	.10
24-in. galv. iron pipe, per lin. ft., in place	4.25

D. P. Olsen, Boise, Idaho, is director, State Bureau of Highways.

Colorado.

The construction program for this year involves the improvement of about 800 miles of road at a total cost of about $4,500,00. Of this mileage 50 miles will be hard surfaced, and the remainder will be graded and surfaced with crushed rock or gravel. The counties will have $2,500,000 for maintenance and new construction. A $5,000,000 bond issue will be voted on next November.

Unit prices varied considerably during 1919 running from $1.90 to $3.10 per square yard for concrete. From $2.80 to $4.10 per cubic yard in place for crushed rock for surfacing. Concrete runs from $18 to $29 per cubic yard for bridge abutments and headwalls. Common excavation which would include loose rock and earth has varied from 40 ct. to $1.50 per cubic yard and solid rock from $1.87 to $2.50. Straight earth work would cost from 28 ct. to 80 ct. per cubic yard, depending upon the amount of work and the location.

At its September meeting the state highway commission appropriated $705,000 for 1920 federal aid projects. The concrete for these roads will be an average of 18 ft. in width, average thickness, 6¾ in., at a cost of $35,000 per mile. The gravel or crushed stone for an 18-ft. 6-in. road will cost approximately from $5,000 to $10,000 per mile.

J. E. Maloney, Denver, Colo., is chief engineer of the State Highway Department.

Utah.

In 1919 contracts were awarded for approximately 85 miles hard surfaced roads (9 miles macadam; 8, bithulithic; 68, cement concrete) and 287 miles graded earth. However, owing to the unfavorable labor conditions and inadequate supply of materials, car shortage, etc., less than 70 per cent of the program was completed—this at a cost of $3,200,000.

The plans of the State Road Commission for 1920, in addition to the unfinished work already under contract, contemplate the construction of 92 miles hard surfaced highways and 289 miles of graded earth roads at the estimated cost of $4,100,000, of which the federal government will contribute $1,680,000.

It is, however, very doubtful whether this program can be successfully carried out unless a marked improvement is shown in 1920 over the adverse labor, material and transportation conditions prevailing in the previous year.

Ira R. Browning, Salt Lake City, Utah, is secretary and engineer of the State Road Commission.

Arizona.

An expenditure of about $4,000,000, half of which will be federal aid is contemplated for this present year.

Thomas Maddoch, Phoenix, Ariz., is state highway engineer.

New Mexico.

The principal item of operation in 1920 will be on the federal aid program. The state has 44 projects, of which 9 are already under contract. Two of these projects (Nos. 15 and 26) are estimated to cost $584,108. The total estimated cost of the other 42 projects is $4,449,221, itemized as follows:

Grading	$1,091,541
Surfacing	2,132,307
Structures	820,894

The total mileage is 613. Of this total 59 miles will be surfaced with caliche, and 21.3 miles with concrete. The remainder will be surfaced with gravel or crushed stone. There also will be a maintenance program and some additional construction with state aid funds.

L. A. Gillette, Santa Fe, N. Mex., is state highway engineer.

Nevada.

An expenditure of $2,000,000 is contemplated for highway construction in 1920. The work includes about 30 miles of concrete pavement and 300 miles of other types, chiefly gravel. Several reinforced concrete bridges are included in the construction program. Plans for the greater part of this work have been completed, and it is proposed to let contracts early in the year.

C. C. Cottrell, Carson City, Nev., is state highway engineer.

Wyoming.

The state highway commission will receive bids and award contracts on road construction projects valued at approximately $1,500,000 early in March. The contracts to be awarded comprise improvements in every county of the state. Plans also will be completed at an early date for additional projects estimated to cost $1,000,000 and bids will be received and contracts awarded probably by April 1. The commission also will receive bids early this month for the construction of four bridges estimated to cost $225,000. The first road letting includes 13 projects, the work requiring 736,400 cu. yd. of embankment, 107,900 cu. yd. selected metal surfacing and 454 culverts.

D. S. McCalman, Cheyenne, Wyo., is state highway superintendent.

PACIFIC COAST STATES.

California.

The state highway commission plans to expend about $10,000,000 this year for highway improvement.

A. B. Fletcher, Sacramento, Cal., is state highway engineer.

Oregon.

During 1919 the state highway commission placed under contract 375.8 miles of pavement, 302.3 miles of macadam and 682.9 miles of grading, the total estimated cost being $18,315,887. The work completed last year was as follows:

Pavement	163.1 miles
Macadam	94.4 miles
Grading	286.6 miles

Of the 375.8 miles of pavement 31.5 miles is 6 in. concrete, Oregon type "A," 57 miles is 2 in. bituminous wearing surface on a 3 in. bituminous base, type "D," and 287.3 miles is 2 in. bituminous surface on a 6 in. new macadam base, type "E." During the 1919 working season, there were completed 18.5 miles of type "A," 35 miles of type "D," and 110 miles of type "E." The balance will be completed during 1920.

In addition to the amount of $18,315,887 shown as being under contract at the present time, there will be approximately $14,000,000 worth of additional work contracted for construction during 1920 and 1921, if legislative appropriations which are now pending at a special session of our State Legislature are favorably acted upon.

The type "A" pavement is costing approximately $2.35 per square yard of completed pavement. Types "D" and "E" are costing approximately $2.05 per square yard of complete pavement. In addition to this amount, 2 ft. rock shoulders on each side of the pavement are costing an average of $2,500 per mile. The grading and preparation of the roadbed for pavement work averages about $1,900 per mile.

The average unit prices on several of construction items for contracts awarded in 1919 were as follows:

Earth excavation, per cu. yd	$ .60
Intermediate excavation, per cu. yd	.80
Solid rock excavation, per cu. yd	1.40
12-in. culvert pipe, per lin. ft	1.75
18-in. culvert pipe, per lin. ft	2.50
24-in. culvert pipe, per lin. ft	3.75
30-in. culvert pipe, per lin. ft	6.00
36-in. culvert pipe, per lin. ft	7.50
Class "A" concrete, per cu. yd	27.50
Class "B" concrete, per cu. yd	25.00
Class "C" concrete, per cu. yd	22.50
Metal reinforcement, per lb	.10
Wood guard fence, per lin. ft	1.25
Broken stone macadam, waterbound, per cu. yd., loose measure	3.50

Herbert Nunn, Salem, Ore., is State Highway Engineer.

Washington.

An expenditure of $3,500,000 is proposed by the state. The program includes about 150 miles of grading and graveling and about 60 miles of 18 ft. and 20 ft. concrete roads. It is planned to place all work under contract by May. James Allen, Olympia, Wash., is state highway commissioner.

Convention of American Road Builders Association.—The annual convention of this association will be held at the Jefferson County Armory, Louisville, Ky., Feb. 9-13.

The program includes the subjects of highway construction, transportation and maintenance; also the administration and financing of national, state, county and municipal highways. Papers and addresses by leading highway authorities and reports on live topics by the several committees of the association will be presented for discussion. The reconstruction period incident to the war has brought about many problems of great importance to the road builders of America and it is proposed to give these problems the fullest consideration. All sessions of the Congress will be held in the Convention Hall of the Armory, one flight above the floor on which will be held the exposition of road and paving machinery, materials, and methods.

Cost of Arizona Federal Aid Concrete Road

The following data relate to the construction of a concrete pavement on the Phoenix-Temple, Ariz., highway, Arizona Federal Aid Project No. 2. The work was done during January and February, 1919, by forces of the Arizona State Highway Department. The cost data cover about three-fourths of the length of road construction. The work involved 2.92 miles of 18-ft. wide, 5-in. thick, 1:2:4 concrete pavement. The total number of cubic yards of concrete placed was 4,397, equivalent to 31,658 sq. yd. of pavement, giving a ratio of 1 cu. yd to 7.2 sq. yd.

The subgrade was composed of an old surfaced road of caliche conglomerate and mixture of decomposed granite and caliche, which was very hard to work. The preparation of the subgrade for the concrete was very expensive, but an exceptionally good piece of work was performed.

The mixing was done with a new No. 22 Koehring paving mixer, using a 3-bag batch. 1.57 bbl. of cement were used per cubic yard of concrete in place; 0.48 cu. yd. of sand, and 0.89 cu. yd of stone. The wooden side forms were 2 in. x 5 in. and were left in place.

Water was pumped a maximum distance of 1½ miles. Trouble was experienced with the pumps as they were of too small a capacity. The pipe was old, and the line was poorly laid.

Common labor and teamsters were paid $3.50 per 8-hour day. State teams were used and were figured at $6 per day for team and driver. The hauling costs were exceptionally high due to poor handling of teams. The crushing costs also were high, due to poor setting of crushing plant, constant breakdowns and changing of foremen.

The organization of the concrete gang was very good, the average daily run being 450 lin. ft. and the maximum daily run 540 lin. ft. The gang was made up as follows:

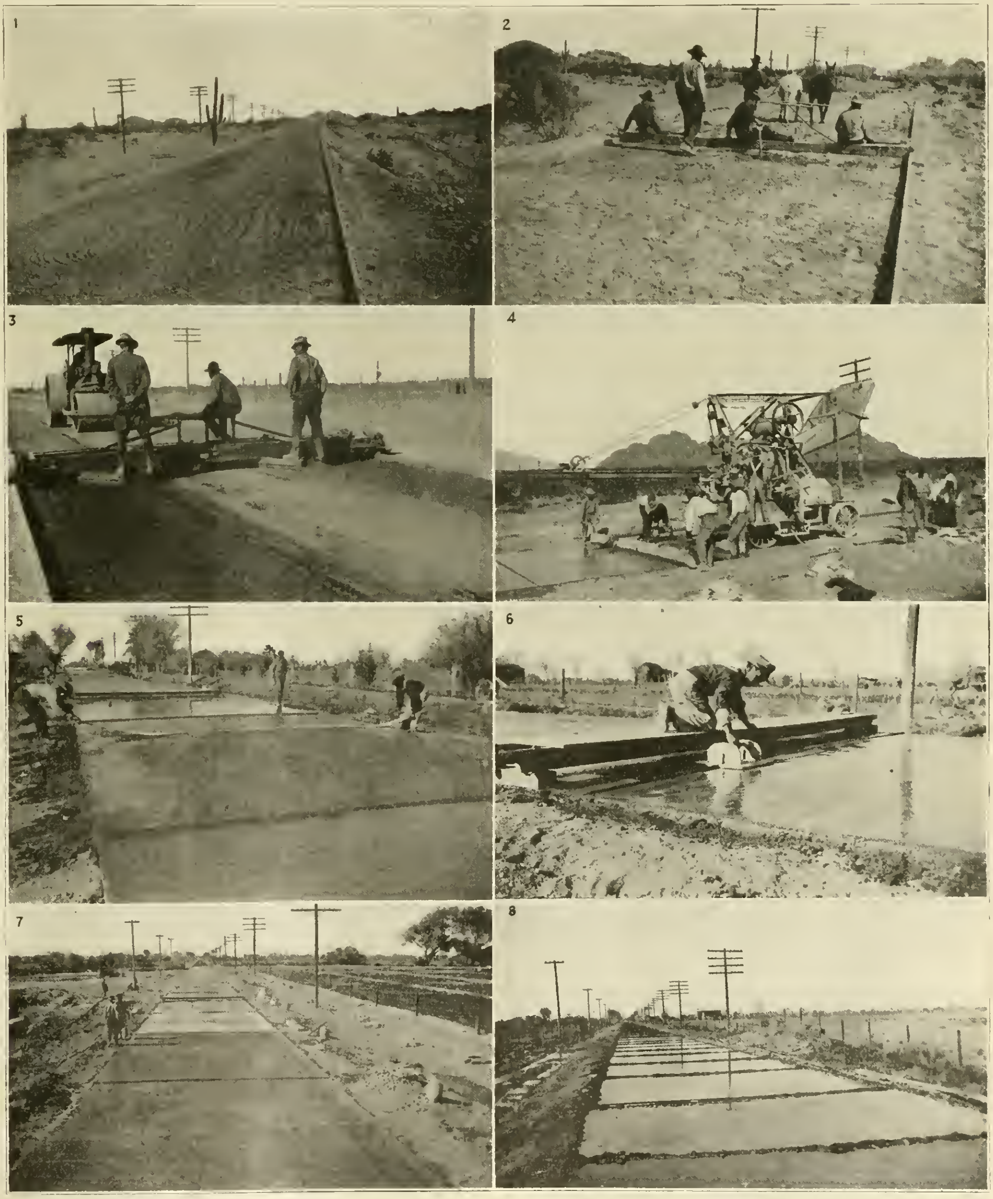
		Per day.
1	foreman	$ 6.00
1	mixer engineer (gas engine)	5.50
1	bucket man on boom of mixer	4.00
1	pump man	4.00
2	finishers, rolling, belting and finishing joints	9.00
2	strike board men (screening and tamping) at $4	8.00
2	concrete spreaders at $3.75	7.50
1	handy man, installing joints, wetting subgrade, etc	3.50
4	men wheeling and loading stone wheelbarrows at $3.50	14.00
2	men wheeling and loading sand at $3.50	7.00
4	extra men loading stone to wheelbarrows at $3.50	14.00
1	extra man loading sand to wheelbarrows at $3.50	3.50
1	man, cement to hopper, from side forms	4.00
1	water boy, also spotting piling of cement	3.00
1	watchman wetting down concrete	3.50
2	men dyking for curing and wetting down concrete at $3.50	7.00
27	men. Total	$103.50

An additional pump man required nights for about one-third of time.

The itemized cost of the pavement was as follows:

	Cost per cu. yd. Concrete.
Labor:	
Supervision (foreman and timekeeper)	$0.08
Preparation of subgrade, including dragging, rolling wetting down, harrowing and trimming	0.57
Setting wooden side forms, including trenching for same. (Forms remain in place)	.45
Loading materials, mixing, placing and curing concrete, pumping water, watchman, cleaning off pavement and cutting expansion joint filler	1.12
Dumping and spreading sand and stone on subgrade	.06
Pipe line, hauling, laying and removing (estimated)	.16
Assembling and dismantling mixer (estimated)	.01
Total labor	$2.45
Concrete Materials:	
Cement—	Per bbl.
F. o. b. Phoenix (net)	$3.17
Loading and unloading	.13
Hauling, average haul 1 mile	.11
Return freight and bag losses (estimated)	.05
Total cost per bbl	$3.46
Cost (1.57 bbl.) per cu. yd. concrete	5.43
Sand—	Per cu. yd.
Premium	$0.10
Hand screening at pit (part of supply)	.40
Loading at pit (total supply)	.40
Hauling pit to crusher (¼ mile bad haul)	.32
Screening at crusher (part of supply)	.20
Hauling to road (3-mile average haul)	1.40
Cost per cu. yd. on road	$2.82
Cost (0.48 cu. yd.) per cu. yd. concrete	1.35
Gravel (State Plant):	Per cu. yd.
Premium	$0.10
Loading at pit	.48
Hauling pit to crusher (¼ mile bad haul)	.32

Crushing and screening	1.02
Hauling to road (3-mile average haul)	1.40
Cost per cu. yd. on road	$3.32
Crushed Stone (Tempe Commercial Plant):	
Cost in bin, $1.85 per ton × 2460 2000	$2.28
Haul to road (3-mile average haul)	1.40
Cost per cu. yd. on road	$3.68
Composite price of gravel and crushed stone	3.50
Cost (0.89 cu. yd.) per cu. yd. concrete	3.11
Total cost cement, sand and stone, per cu. yd. concrete	9.80
Expansion joints (Carey's Elastite)	.10
Materials and Repairs:	Cost per day.
Mixer—	
Gasoline, 22 gal. at $0.25	$ 5.50
Oil, grease, waste, etc	1.00
Cost of 50 days	300.00
Pumps—	
Gasoline, 8 gal. at $0.25	2.00
Oil, grease, waste, etc	.50
Cost per day	$ 9.00
Cost of 50 days	450.00
Crushing Plant:	
Coal, ¾ ton per day at $7.50	$ 5.00
Oil, grease, waste, etc	1.00
Cost per day	$ 6.00
	Lump sum.
Repairs on mixer (estimated)	$ 20.00
Repairs on pumps (estimated)	200.00



A Concrete Road in the Making—Construction Views of Arizona Federal Aid Project No. 2—Phoenix-Tempe Highway.

(1) Harrowed Surface Ready for Rolling. (2) Log Drag Leveling Subgrade After Completion of Rough Grading. (3) Carr Subgrader on Final Trimming of Road. (4) Depositing Concrete; Strike Boards Were Close Up to Concrete Placing at All Times. (5) First Passage of Belt With Long, Sweeping Stroke. Note Ridges Left by Roller and Hand Finishing Along Edges. (6) Using Wooden Split Float From Bridge. (7) 540 Lin. Ft. Day's Run. (8) Curing Concrete Pavement by Ponding.

Repairs on crusher (estimated)	500.00
Total cost, fuel and repairs	$1,470.00
Side Forms and Stakes:	Per station.
Side forms, 200 ft. B. M. at $45.00	$ 9.00
Stakes and nails	1.00
Total cost for 28 yd. concrete	$ 10.00
Interest and Depreciation:	Lump sum.
Mixer cost, $4,360, at 10 per cent	$ 436.00
Two pumps and engines, $400, at 10 per cent	40.00
Pipe line, connections, etc., $5,000, at 10 per cent	500.00
Car subgrader, $400, at 10 per cent	40.00
Small tools, hose, etc., $500, at 50 per cent	250.00
Cement house, $300, at 50 per cent	150.00
Crushing outfit, $4,000, at 15 per cent	600.00
Dump wagons, $3,000, at 10 per cent	300.00
Total interest and depreciation	$2,316.00

SUMMARY OF COST.

	Per Cu. Yd. Concrete in Road.
Labor	$ 2.45
Cement	5.43
Sand	1.35
Gravel and crushed stone	3.11
Expansion joints	.10
Materials and repairs for plant	.33
Side forms and stakes	.36
Interest and depreciation on plant	.40
Total per cu. yd. concrete	$13.53
Total cost of concrete pavement per cu. yd	13.53
Total cost of concrete pavement per sq. yd	1.88

The finished concrete road was an exceptionally good piece of work.

The improvement was carried out under the supervision of Clyde E. Learned, Senior Highway Engineer, U. S. Bureau of Public Roads, to whom we are indebted for matter in this article.

Engine Hitch for Small Grader

To meet the demand of road contractors, county and township road engineers who are using small tractors in road work, the Smith & Sons Mfg. Co., Kansas City, Mo., manufacturers of the Royal line of road building machinery, has perfected an engine hitch for the Little Giant road grader.

Steel construction is used throughout the engine hitch and the attachment is under the complete control of the operator on the rear platform. The pipe tongue is easily set at any angle and remains in position without locking, the gearing being self-locking. It is readily and quickly adjusted to another angle without stopping or slackening the speed of the machine. The tongue remains fixed at the angle set, and the grader travels a corresponding distance from the point of draft on engine, yet the axle is free on the king bolt.

Sufficient power to successfully operate the grader can be secured with any light tractor. Extensive tests have been made of the attachment, especially on the Pacific Coast, and it has performed admirably. Motor trucks of 2, 2½ and 3 ton capacity have also been successfully used as motive power.

Engineers' License Laws for Ohio, Kentucky and West Virginia.—Engineers in Kentucky, Ohio and West Virginia have recently taken action to bring much nearer the enactment of a license law in each state. The legislature of Kentucky is reported favorable to a license bill recently introduced under the auspices of A. A. E. members in Louisville. The bill is patterned after the Michigan law. At the recent meeting of the Ohio Engineering Society steps were taken to organize the engineers of the state to insure agreement among them on the desirability of a license law and to bring their influence on the next legislature. At a joint meeting of the West Virginia Engineers' Association and the Charleston Chapter of A. A. E. in Charleston on Jan. 23, licensing was discussed by Secretary Drayer of A. A. E. who recommended with minor changes the registration bill proposed by engineering council. A motion was passed empowering the presidents of the West Virginia Engineers' Association and the Charleston Chapter to appoint a joint committee to prepare a bill for passage by the legislature which meets in 1921.

Advance Material Estimates for Wyoming Road Contractors.—With a view to expediting the work this year's contracts of the Wyoming State Highway Department allow on contractors' monthly estimates the value of materials delivered in advance of time required. Contractors also will be allowed on monthly estimates the premium paid for surety bond as evidenced by receipt for same.

Mineral Aggregates for Bituminous Pavements*

By WALLACE L. CALDWELL.

Director, Department of Roads and Pavements, Pittsburgh Testing Laboratory, Birmingham, Ala.

The writer has investigated a large number of failures of different types of bituminous pavement, and has endeavored to differentiate the causes and percentage of failure. The percentages given below are not of universal application, but represent approximately the causes of failure encountered in the writer's investigation. The failures considered are failures of the wearing surface as distinct from failures caused by improper subgrade and foundations.

	Per cent.
Unsuitable mineral aggregate	30
Improper manipulation at mixing plant	25
Poor workmanship on street	15
Bad weather conditions	15
Bitumen of improper consistency	10
Bitumen unsuitable for paving	5
	100

In spite of its importance, it is only recently that general attention has been given to the physical testing of aggregates for bituminous pavements. Even today, most specifications are extremely vague and indefinite as to the quality of aggregate materials. The specifications of the United States Bureau of Public Roads, of several state highway departments and of a few cities have recognized the value of such tests, and have made their requirements as definite as the present state of our knowledge of physical testing permits. Hundreds of specifications are being prepared every year in which even the data available at present are not recognized. The only definite test commonly specified is the mechanical analysis as determined by laboratory sieves. Aside from this test, the acceptance of aggregate materials is ordinarily based upon visual examination and personal opinion, both of which have their value, but some more definite standards are needed, especially in these days when many inferior materials are being used, often under the supervision of men of limited experience.

In this article only the aggregate materials commonly used in mixed method pavements will be discussed.

Essential Properties of Sands for Bituminous Pavements.—It is the writer's opinion, and the experience of others seem to bear this out, that for paving purposes satisfactory results are in general obtained only from quartz sands.

Sands may be classified, as to source, as beach, river and bank sands. A great variety of sands are found in each class, but in general the sands of greatest value are secured from rivers and banks, although many sands from the beaches of the Great Lakes have been used satisfactorily. Sea-beach sands are sometimes used, but as a class are not so satisfactory as the other sands mentioned.

Before discussing the physical properties which are necessary in a sand, it may be stated that very little real quantitative data regarding the physical properties of sands for bituminous pavements are available.

The writer is glad to report that certain investigations have been under way in his laboratories for some time, and that progress is being made. In due time results will be secured which will be of value. In the meantime, we can best secure satisfactory results by availing ourselves of the information which has been accumulated through experience and observation. Although this information is large empirical, it serves as a useful guide.

Both theory and experience have shown that sands having angular grains are best suited for bituminous pavements. Rounded grains do not have as many points of contact as angular grains, and, therefore, a mixture in which such grains are used is not stable and is more readily displaced by traffic than a mixture containing angular grains. This applies to sand used in both fine and coarse aggregate pavements.

In order that a film of bitumen of sufficient thickness may adhere to each sand grain, the surface of the grain should be somewhat rough or pitted. Sands with smooth and polished grains are frequently encountered, but their use should be avoided, because the individual grains are sometimes so thinly coated with bitumen that a proper bond between the different particles of the mineral aggregate cannot be secured.

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*From a paper presented at the last annual meeting of the American Society for Municipal Improvements.

The sand grains should be hard and tough, so that the individual grain will not readily wear away under the abrasion of traffic nor fracture under impact. Of course, the small size of the sand grains and the cushioning action of the bituminous cement so largely reduces the danger of fracture that toughness is a much less important factor than in the case of aggregate of larger size, such as gravel and crushed stone. Several failures have been attributed to the use of sands with soft grains.

As yet no satisfactory means of ascertaining the hardness and toughness of sands have been devised. There is, however, a need for such tests, and in connection with the investigations previously mentioned the writer has developed certain methods for making these tests. Before arriving at any definite conclusion as to the value of these tests, it will be necessary that many check tests of several hundred different sands be made.

The amount and character of the impurities found in a sand largely determine its value. Clay, loam, mica and organic matter are common impurities, and in sufficient amount each one is a most important factor in determining the quality of a mixture.

Clay is found either finely divided and evenly distributed through the sand or in the form of small clay balls. If only a small percentage of clay is present in a finely divided state, and the clay itself is not plastic, little harm will be done; in fact a large percentage of the clay will be removed by the fan on the heating drum of the asphalt plant. However, if the clay is plastic and present to the extent of more than 5 per cent, the sand grains will be coated with a hardened film of clay after passing through the drum. This film will prevent the bitumen from adhering to the actual surface of the sand grains. The film of bituminous cement is easily broken away from the sand grains, permitting water and traffic to disintegrate the pavement.

Clay balls, when present in any appreciable quantity are a source of even greater danger than evenly distributed clay, and engineers should take a decided stand against the use of sands containing such material, because disintegration is quite certain. The clay balls at the surface of the pavement are removed by water and traffic. This allows water to gradually work down into the pavement, softening the clay balls scattered throughout the mass. Eventually this results in serious disintegration of the pavement surface. This condition is of more common occurence than is often realized.

In certain localities where the sands have been formed by disintegration of granites and gneisses, mica is almost a universal constituent of the sands. If present in any appreciable amount, trouble may be experienced, since the mica grains cannot be satisfactorily coated with bitumen and will not resist traffic. In practice the writer has ordinarily rejected sands containing over 3 per cent of mica, as estimated with the microscope.

Organic matter, usually in the form of roots, twigs and leaves, is found in many sands. When the hot sand is screened through an 8-mesh screen, as in the case of sheet asphalt, the greater portion of such material will be removed, but when the type of pavement requires the use of a larger size screen, the roots and twigs will pass through into the mixture. Such material in the mixture is a source of weakness, and either the sand containing it should not be used or else it should be screened out.

The grading of sand is, of course, one of its most important properties. In fact, experience and theory have demonstrated most clearly that the grading must be within certain narrow limits if satisfactory results are to be secured. Sand is used in several types of pavement, both by itself and combined in various percentages with several kinds of coarse aggregate, but in every class of pavement the grading of the sand is an important factor. From the standpoint of the practical asphalt man, sands are often classified as fine, medium and coarse.

The fine sand contains a high percentage of 100 and 80-mesh grains, the medium a high percentage of 50 and 40-mesh material, and the coarse a preponderance of 30, 20 and 10-mesh grains. In most localities, medium and coarse sands of proper quality are more readily secured than the fine. Sands containing a sufficient percentage of the fine 100 and 80-mesh grains must be found, since without these fine grains a satisfactory pavement will not be produced, regardless of the type of pavement. An engineer is fortunate, indeed, who can find one sand which will fill all requirements as to grading. Such sands are found but they are rare. Ordinarily mixtures of two, three and even four sands must be made in order to produce a properly graded aggregate.

Specifications customarily fix the percentage of 200-mesh sand at a maximum of 5 per cent. This limitation is based upon sound reasons and should be invariably followed, in fact, it has been the writer's practice to limit the 200-mesh sand to 3 per cent whenever possible. The 200-mesh material in a bituminous mixture should be composed of filler, and not sand. Sand grains, even though they pass the 200-mesh sieve, are much coarser than the greater portion of a properly ground dust, and do not function as a filler in any respect. Sands containing up to 10 or 12 per cent of 200-mesh grains have been used with little or no filler, it being assumed that since the percentage of the 200-mesh material was within the required limits, no other material of this size was needed. Such mixtures are unstable and invariably result in failure.

Too frequently, the sands most readily available, even though not entirely satisfactory, are used. Usually a brief investigation and a sand survey will locate other supplies within reasonable shipping distance. Quite commonly the new supplies will be better than those previously available, particularly in those regions where suitable sands have not been developed owing to lack of demand. Before deciding upon the sands to be used on any job the writer has invariably investigated all possible sources of supply, both developed and undeveloped. The results obtained have usually justified these investigations.

Properties of Filler for Bituminous Pavements.—Filler, which is finely ground mineral dust, is ordinarily used in all types of mixed method pavement, except bituminous concrete pavement with a mineral aggregate of crusher run stone or pit run gravel. Its use produces a dense pavement, reduces liability of displacement, enables a softer asphalt cement to be used, and causes the surface to be less susceptible to damage from water.

An ideal filler should be finely ground, not merely so that a considerable percentage will pass a 200-mesh sieve, but so that at least 60 per cent will be a true dust or impalpable powder, as determined by the elutriation test. It is this powder which really serves as the filler and which produces the results required of a filler. The remaining portion of the filler simply serves as sand.

The grains of the filler should have a surface which will absorb a heavy film of bitumen. Very hard dense grains do not absorb a sufficiently thick film of bitumen to permit such grains to fulfill all the functions of a filler even though the material be ground to the requisite fineness.

The filler should be so constituted, chemically, that it will have no harmful action upon the bitumen and so that water will not in any way react with the material. The material should not be light and fluffy but should have a weight of at least 90 lb. per cubic foot. Lighter materials are readily blown away when being placed in the mixer, with the result that the mixture has a variable and always low percentage of filler. Closed mixers eliminate this difficulty, but are found on only a few plants. Light-weight fillers, when used in sheet asphalt, often produce a fluffy mixture, which will not rake well and which does not take compression as it should. Among the fillers commonly used are portland cement, ground limestone, slag dust and ground silica. Nearly every kind of pulverized mineral has been used at one time or another. Practice has clearly shown portland cement to be the most successful filler, and limestone dust to be relatively second in value. Portland cement seems to produce a somewhat denser mixture than any other filler, and when heavy traffic must be provided for, its use is advisable. The reason for this is somewhat obscure, but principally is due to the slightly porous nature of the portland cement grains. This property results in each grain absorbing a certain amount of bitumen, and permits the formation, around the grains, of a tenaciously held and rather thick film of bitumen.

Limestone dust has been used with entire satisfaction.

Slag dust has not been extensively used but has given good results wherever used. It would not be advisable to use the dust from an acid slag, because of the hard, glassy nature of the material, but no criticism can be made of the dust from a basic slag. Silica dust from a number of different sources has been widely used. No serious trouble has resulted from its use, but in general it has not given as good satisfaction as certain other materials.

Good filler is scarce today, the production having fallen below the demand. Many products which cannot be classed as a dust in any respect are being offered. Products having 50 per cent of material passing the 200-mesh sieve but containing very little actual dust as determined by the elutriation test, are not uncommon. In several cases agricultural limestone containing 20 or 25 per cent of 200-mesh material, with coarse grains as large as ¼ in., has been used and has been called filler. Ground stone such as this contains no true dust and simply serves as a source of fine and intermediate aggregate, with the result that the mixture contains no filler.

Coarse Aggregates for Bituminous Pavements.—Limestone, dolomite, trap rock and granite are the rocks most commonly used in bituminous construction, although sandstone, gneiss and certain other rocks have been used to a limited extent. The rock should be sufficiently hard to resist the abrasive action of traffic and tough enough to withstand the impact of iron-shod hoofs and of vehicles. It should be clean and free from clay. If the rock contains fine screenings it should be freshly crushed, since the dust tends to collect on the surface of the larger pieces and, if once wet, forms a scum on the surface, which is dried and baked when the stone is passed through the heating drums. This film effectually prevents the adherence of the bitumen to the surface of the rock.

The individual pieces should be as nearly cubical as possible, since stone which crushes in slabs or slivers produces a mixture which cannot be compressed to as great a density as if a stone of cubical fracture is used.

Slabby pieces of stone are more easily fractured by traffic and thus are likely to cause the pavement to ravel. A stone having a structure and surface which will permit of absorption of a certain amount of bitumen is to be preferred to a stone with a hard, dense surface which will permit of no impregnation.

Fortunately, satisfactory physical tests have been devised for rock. The U. S. Bureau of Public Roads and others have made thorough investigations of the methods and interpretations of these tests. Hubbard and Jackson, in Bulletin 370, U. S. Department of Agriculture, have tabulated a great amount of data and have given valuable interpretation of the results of their tests. Too few specifications call for these tests.

It has been the writer's experience that for city pavements, subjected to ordinary traffic, no rock having a French coefficient of wear of less than 8, or a toughness of less than 8, should be used. Under very light, residential traffic it is sometimes permissible to permit the use of a rock with a toughness of 7 and French coefficient of 6, but under no circumstances should an aggregate of lower value be used. For heavy city traffic, the requirements should be increased to a French coefficient of wear of at least 10 and a toughness of between 10 and 14, depending upon the density and nature of the traffic and the size and character of the aggregate. Binder stone should have a toughness of at least 7. Of the two tests, toughness is undoubtedly of the greater value when considering the quality of rock for a bituminous pavement.

The grading of the crushed stone is of vital importance, and in bitulithic and asphaltic concrete pavements, it is given careful attention. The density of any coarse aggregate mixture is dependent upon the proper grading of the stone. In some cases, stone as received from the quarry may be of the proper grading, but often a combination of crushed stone of different sizes must be used. In bitulithic pavement the stone is screened into various sizes, each size stored in a separate bin and re-combined in the proportion desired by weighing a definite amount from each bin.

Since their use is rather widespread, it will be well to mention chats or trailings from certain ore mines. The two materials of this class most commonly used, at least in the east, are from the zinc mines of eastern Tennessee and the Joplin, Mo., district.

The Tennessee chats are a limestone, averaging 97 per cent calcium carbonate, are very hard and tough, and have an unusually high specific gravity and a decidedly cubical fracture. The surface of the pieces of rock is perfectly clean, washing being a part of the ore-dressing process. Most excellent results have been secured from this material.

The Joplin chats are a flint, are hard and tough, have a good cubical fracture, and are clean, but have a very smooth surface which does not hold a thick film of bitumen. However, excellent results have been obtained in many pavements with these chats. In the process of manufacture both materials are so crushed that they will pass a 2-mesh sieve. They are, therefore, used almost entirely in asphaltic concrete pavements of the Topeka type.

Crushed blast furnace slag has in the past been used to a limited extent in the wearing surface of bituminous pavements. Its use is increasing, and it has been recognized as a satisfactory aggregate material, used by a number of cities and counties, and at least one state highway department—that of Ohio. Slag has been used in some bituminous pavements for several years, with apparently good results. The writer has had certain pavements in which slag aggregate was used under observation for the past 2½ years. No trouble which can be attributed to the slag has developed as yet.

Two general classes of slag are available: (1) Basic, containing a high percentage of lime and magnesia and a relatively low percentage of silica; and (2) acid, containing a higher percentage of silica. Basic slags are tough and hard, whereas acid slags are often brittle. Basic slags have a porous and somewhat absorbent surface; acid slags have a glassy surface, which is unsuited for bituminous pavements. Ordinarily, basic slags only should be used. The following are typical analyses of the two classes of slag:

CHEMICAL ANALYSES.

	Basic. Per cent.	Acid. Per cent.
Silica	35.55	39.50
Alumina	12.04	14.00
Iron oxide	.62	.52
Calcium oxide	41.35	40.00
Magnesium oxide	8.45	4.00
Total sulphur	1.28	1.32
PHYSICAL TESTS.		
French coefficient of wear	6.2	3.6
Toughness	14.0	6.0
Hardness	15.6	15.5

Slag is more difficult to test than rock, due to greater difficulty in securing representative and suitable samples for some tests, but usually the methods of testing used for rock meet all requirements. Slag should not be too badly honeycombed and should be clean and free from blast-furnace downcomer dust. It has been thought by some that possibly some constituent of slag is harmful to the bitumen. Sulphur is usually the constituent blamed, but it is clear that there is no sound reason for this opinion.

Gravel has been used as a coarse aggregate in nearly every type of bituminous pavement. Because of the nature of the material and the characteristic rounded grains, it does not give as satisfactory results as a crushed stone. When crushed stone is used, the angular fragments will key together and the results will be better than if rounded gravel is used.

Many gravel deposits contain clay, either evenly distributed or in the form of clay balls. The results will be about the same as in the case of sand containing clay.

Toughness and hardness tests are not made on gravel, but the coefficient of water is determined either by the Deval method used for rock, or by a modified method in which six cast-iron spheres, 1.975 in. in diameter and weighing 0.95 lb., are placed in the cylinder with each charge. The French coefficient of wear on a good gravel will be above 12. The mechanical analysis of gravel is of great importance, and every effort should be made to keep the grading within the proper limits for each type of pavement.

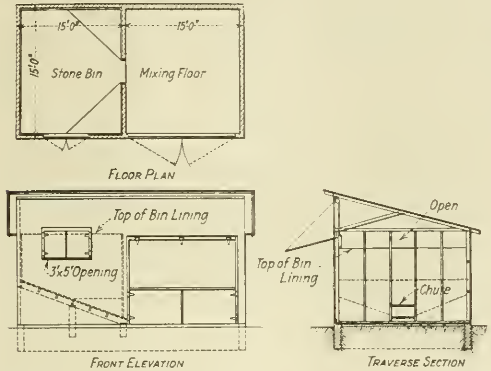
Engineers Club of Kansas City Amalgamates with A. A. E.—The Engineers Club of Kansas City voted on Jan. 27 to amalgamate with the American Association of Engineers as the Kansas City Chapter. The vote was 143 in favor to 38 against the amalgamation. A new constitution was adopted and officers were elected for 1920 as follows: Clark R. Mandigo, president; F. F. Schauer, vice-president; A. Penn Denton, 2nd vice-president; Forrest Kauffman, secretary; Wm. Bugg, treasurer, and W. A. Collins, Edmund Wilkes, Jr., and A. R. Young as members of the executive committee.

Highway Maintenance by Gang Patrol System

Patrol gangs working from centrally located district stations have proved very effective in maintaining the highway system of Lucas County, Ohio. The methods and some of the results obtained were outlined in the Nov. 5 issue of Engineering and Contracting. Further details were given by Mr. C. L. Rood, County Engineer, in a paper presented Jan. 22 at the annual meeting of the Ohio Engineering Society.

The highway system consists of 117.5 miles of waterbound macadam, 173 miles of bituminous macadam, 2.5 miles of brick, 26.5 miles of concrete, 3.5 miles of asphaltic concrete.

The county is divided into five districts. Centrally located in each district is a patrol station. This station is 30 ft. x 15 ft. and has a 15 ft x 15 ft. concrete mixing floor at one end, a stone bin holding a carload of stone at the other, and a 00 gal. tank wagon for bitumen. Two patrol gangs are each equipped with a 2½ ton truck, a 6 cu. ft. batch concrete mixer and a camp wagon. The latter is a frame house, about 7 ft. x 10 ft. mounted on standard wagon running gear. Each gang consists of truck driver who is foreman, and three men.



Layout of District Road Patrol Station of Lucas County, Ohio.

The improved road mileage is so arranged that the bulk of the heaviest traveled roads which are in the immediate vicinity of Toledo are covered by District No. 1. The mileage in Districts 2 and 3 and 4 and 5 are so arranged that their combined totals are about equal. District No. 1 is taken care of jointly by both patrol gangs No. 1 and No. 2. Upon the completion of work in this district, gang No. 1 goes to station No. 2 and then to station No. 3, while patrol gang No. 2 goes to stations Nos. 4 and 5. The work has been so uniform the past year that the two gangs have arrived back at station No. 1 within ten hours of each other, every trip last summer.

The patrolman arrives at a station, unloads his concrete mixer, uncouples his camp wagon from the truck and makes camp. He then thoroughly mixes about 20 cu. yd. of bituminous concrete, using ¾ in. stone and about 17 gal. of bitumen cut back per cu. yd. of stone and allows the same to set up for 12 or 18 hours. This mixture is then loaded on the truck for delivery. As the roads are patroled, each hole that develops is cleaned out, filled with the bituminous mixture and thoroughly tamped—traffic does the rest.

Each day the patrolman in charge of each gang mails to the office a post card report detailing the work of the day before—showing roads patroled, number of miles covered, number of square yards of patches, number of hours devoted to mixing, cleaning out holes and patching, number of gallons of bitumen used, number of gallons of gasoline and oil consumed by truck, and number of men working and hours worked; also stating on what roads they can be found the two days following the writing of the report.

Patrol Gang No. 3 is equipped with tools, paints, shovels, brushes and lumber, and is known as the flying squadron. It reports each night to the county deputy of maintenance and repair, and gets instructions for the following day. This gang fixes broken guard rail, repaints small bridges and keeps guard rails painted white, erects warning and danger signs and maintains them after erection, fixes wash-outs in bermes, etc., and takes care of all emergency jobs of a small nature that arise.

Gang No. 4 is the "heavy artillery" of the forces and is equipped with two 10-ton gasoline road rollers equipped with scarifier, graders, dump wagons, water wagons, and small tools. This gang since April, 1916, has practically rebuilt 48.7 miles of waterbound macadam and placed it in condition to surface treat and maintain. The gang first cleans out all ruts and holes in a waterbound macadam road and sweeps it clean with a gear-driven broom sweeper. The deep depressions and holes are then filled with stone 2½ in. to 3½ in. in size and the entire road is then scarified, dragged and leveled; a 4-in. wearing course of new 1½-in. to 3-in. stone is spread through the center 10 ft. of the road, and this is feathered out to the edges to obtain sufficient crown. The entire width of road is then screened and waterbound, and when completed is practically the equal of a new macadam road. After this the road is given a surface treatment of bitumen and maintained by patroling.

The 1919 costs which are but a trifle in excess of the average for the past four years, are as follows:

Gangs No. 1 and No. 2 placed in the season of 1919, 32,062 sq. yd. of patches, while maintaining 243.5 miles of road and covered 733.12 patrol miles at an average cost of 39.4 ct. per per square yard, an average cost of $51.78 per mile of road, or an average cost of $17.20 per patrol mile. The total cost of operation, including overhead, repairs to trucks, etc., was $12,607.

Gang No. 3, beside painting almost 3 miles of guard rail, erected 172 danger signs, marked state routes by stenciling and painting signs on over 500 telephone poles, attended to 57 wash-outs, repaired and painted 16 small bridges and maintained 12.7 miles of concrete roads by filling joints and cracks with pitch and did innumerable odd jobs at a cost of $3,787.

Gang No. 4 rebuilt 13.5 miles of waterbound macadam totaling 105,727 sq. yd. at an average cost per square yard of 46.2 ct., or $3,621.40 per mile, and spent, including new equipment, repairs, overhead, etc., $48,889.

The scale of wages paid during 1919 averaged 50 ct. per hour. Broken stone cost $1.60 per ton, including freight; and bituminous material (cut back) cost 16 ct. per gallon.

Cementing Value of Gravel Not Wholly Dependent in Clay Content

Tests of gravels made by the Iowa State Highway Commission indicate that the cement value of Iowa gravels for road building purposes does not always depend upon the amount of the clay content. According to the November-December Service Bulletin of the commission many of these tests have shown that when clay was entirely washed out of the sample, its cementing value was higher than with the original clay content. Gravel samples are first tested unwashed as received. The gravel is then thoroughly washed and is given another test. It will be found interesting to compare the relative values as received with the clay and after being washed. One sample, for instance, tested 276 with its clay content but only 43 after the clay had been washed out. Another tested 105 as received with its clay content but its cementing value after the clay had been washed out rose to 285. Another tested 116 with its clay content intact hut its value rose to 336 after its clay had been washed out. A fourth sample tested 500 with its clay and 500 after it had been washed, the presence or absence of the clay showing no change.

The lesson to be drawn from the test so far, states the Bulletin, is that the cementing value of the gravel for road building purposes cannot be determined simply by making a clay test. The gravels which show a high cementing value with the clay intact, as a general thing pack more quickly under traffic than the gravel which has a high cementing value without the clay content. The clay free gravel which packs is much more slow to bond when placed on a road but when it does become bonded and well packed it forms a very hard and stable road surface.

The Value of Highway Transport Surveys

In the field of highway transport there has been a colossal number of failures and reports of new transportation companies that have failed are received almost daily. If the money losses represented by these failures—failures due in a large part to the absence of transport surveys—were the sole reason for the development of such surveys, their value would run into millions.

In a paper presented Jan. 29 at the annual convention of the National Highway Traffic Association, Mr. F. Van Z. Lane, Chief Transportation Engineer, Packard Motor Car Co., shows how proper transportation surveys will probably prevent the failures of so many highway transport lines and will also increase the effectiveness of those lines already in existence. An abstract of the paper follows:

Insurance against failure is, however, but a small part of the real value of highway transport surveys. Many companies in existence today would, if such investigations were generally resorted to, be able to render greater service to the public and make increasing profits for themselves, and these surveys would undoubtedly establish the desirability of highway transportation lines where as yet such lines have not even been thought of.

The prevalence of failures, paralleling the failures in the automotive industry in its early days, and the number of lines that are operating with a minimum of benefit to themselves and to their public, indicates the most cursory analysis of the territory to be served, or no analysis at all. Many firms are floundering without chart or compass and we should all do ail in our power to correct the prevalent opinion that all that is necessary is to buy a motor truck of any make you please and any capacity offered, to start it operating over any road available, during any time of the day or week when the driver feels like it, and to charge any price for his services that may come into his head just so long as it is lower than any other price charged for transportation between the points in question.

Just as long as the public has this picture of motor transport lines, just so long will the motor truck incompletely realize its effectiveness. That it can be effective has been proven beyond a doubt. As a mechanical device it has demonstrated its dependability and durability and we have enough experience to know that economically it can perform, and must be made to perform more and more, its function as part of the transportation system of this country.

We are considering the value of highway transport surveys at a time when many business problems of vital importance are pressing for solution. Living costs are high. Labor is scarce. The railroad car shortage is acute and the thousand problems of production are crowding in upon us daily. In all of these problems of our complex business life, there is no factor that affects every phase of economic activity more fundamentally than does transportation. It is, we might say, the very life blood of business and everything that we can do to increase transportation facilities, decrease transportation costs and shorten the time in transit is a vital benefit. Highway transport surveys are, then, not only desirable, but at the present juncture of business conditions, fundamentally necessary.

If we are to survey the field in the broadest and most constructive manner, we must do so in conjunction with a survey of other and longer established means of transportation, especially the steam and electric railways. As an aid to these already existing systems, extending their usefulness in many territories, and even replacing them where such practice proves economically desirable, the motor truck has a tremendous field of usefulness. Just where this usefulness begins and ends, how to cover all territories thoroughly and yet avoid duplication of effort can only be ascertained by complete and far-reaching surveys.

Traffic experts of the railroads themselves are giving deep thought to the availability of the motor truck in supplementing their present facilities. The present shortage of both track mileage and of freight cars makes the subject a most pressing one for the railroads and a most encouraging one for us who are interested more especially in the automotive branch of transportation.

No general survey of the field of highway transport would be complete that left out of account its use in districts now without rail facilities. Mines, forests and quarries situated in remote sections are generally exploited by big organizations with financial backing sufficient to solve their own transportation problems, and many of them are finding their solution in the use of the motor truck.

In the farming sections, however, where the productive unit is comparatively small, there has not been the same incentive for big business to make a thorough survey of conditions and here there is a tremendous field of opportunity.

The hauling and delivery problem of every business should be surveyed in order that the most efficient means of transportation can be used, particularly in reference to the highways. It is astonishing how little most concerns know about the cost of the delivery and hauling end of their business. The concern that usually knows its labor, production, accounting and selling costs, many times has no idea of what its delivery cost is. Yet the delivery and hauling part of the business usually amounts to a great deal. A survey of such a problem will often indicate that it would be more economical to ship or deliver by motor truck than by horse-drawn vehicles, railroad freight or express, or by boat or electric railway. In considering a transportation system the nature and character of the business it serves should be considered first.

The proper kind of a survey will bring out all the items entering into the cost which would never be brought out in any other way.

The proper sized truck, the most adaptable kind of body, and the use of loading and unloading devices will many times serve to handle the hauling problem more economically and more efficiently.

Such a survey should take us behind the lines, so to speak—back of the loading platform into the shipping room, where we could consider such items as boxing, crating, sorting, assembling, routing, internal delivery, etc. It is here that, oftentimes, a study will show how the use of highway transport can cut down the cost of the work leading up to placing the material on the truck or on the car.

In making surveys relative to the establishment of highway freight transport lines, the following items should be carefully considered:

All year round road conditions, including bridges.

Rail freight and express rates.

Frequency of existing service.

Time of delivery of existing service.

Amount of, and kind of, freight moving in both directions between the points in question.

Running time possible.

Sentiment of the district under consideration toward existing and proposed service.

Sufficient financial support.

Traffic laws, ordinances and regulations.

Road conditions will determine the kind of equipment that can be operated. The amount and kind of freight will determine the size of the unit, and number necessary, from which can be determined the expense, to which should be added (this is most often omitted) overhead charges, by which I mean the cost of soliciting business, storing and handling of same, superintendents, etc., and which for such lines runs very high. The cost of operation will determine the rate. This compared with existing rates and services will determine whether or not business can be secured under such costs. The possibility of promoting return loads should not be forgotten. This, you will note, is quite different from the usual method of arbitrarily determining a rate, which is probably that charged in some other locality and without knowledge of actual conditions.

In a survey of the possibility of establishing inter-city motor truck routes out of a certain city recently made, we concluded the lowest capacity truck that could be operated, considering the rate that could be obtained, would be a three-ton size. Yet the operators disregarded our advice and started in with two ton trucks. If loaded to 80 per cent of their capacity on every trip, in both directions, they couldn't pay and didn't—the result being the failure of another line and the loss of much confidence.

Willite Paving in an Arid, Rockless District

By FRANK REED.

The city of Los Angeles, California, and the port of San Pedro are connected by Harbor Boulevard. Most of this highway had been paved with oil-bound macadam, but a fill across "Nigger Slough" has remained unpaved because there has been a sinking each year, sometimes amounting to as much as 3 feet, at the time of the spring rain. This stretch was paved last summer.

This highway carries a very heavy traffic as compared with most western roads. A traffic census taken by officials of Los Angeles county between July 1st and Nov. 1st, 1919, showed a total of 502,583 motor vehicles, of which 59,783 were trucks. The vehicles averaged 4,086 per day and the average daily tonnage was 6,043. There is a large shipyard at the harbor where several ships are constantly under construction, and the heavy steel for these is trucked over the boulevard.

Figures are available of one heavy haulage unit consisting of a specially constructed trailer weighing 6 tons and carrying a load of 20 tons, drawn by two-trucks each weighing 6 tons and carrying a 7-ton load; a total weight of 52 tons.

Local conditions here include absence of both water and rock, thus making excessive the cost of concrete for base or finished pavement.

The pavement laid last summer included the fill across "Nigger Slough" and the surfacing of some old macadam, totaling approximately a mile in length. The material employed was Willite, which used as the sole aggregate the light, drifting sand, a trifle loamy, found along the highway, and a binder of asphalt treated with copper sulphate; this binder being the special feature of this kind of pavement. The dune sand used, when subjected to sieve analysis, tested as follows:

	Per cent.
Passing 200 mesh	6
Passing 100 mesh and retained on 200	48
Passing 80 mesh and retained on 100	28
Passing 60 mesh and retained on 80	14
Passing 40 mesh and retained on 60	3.5
Passing 20 mesh and retained on 40	1.0
Retained on 10 mesh	0.0

No broken stone was used; and the only water used was for the steam boilers of the road roller and asphalt plant and for the men and animals on the job. The mixture consisted of the following, per 747-lb. box.

	Lb.
Sand	650
Asphalt	75
Limestone dust	20
Sulphate	2

No hauling was required for 87 per cent of the material, the sand being dragged to the mixing plant by means of Fresno scraper. The cost of the mineral aggregate, delivered in the mixer, was figured by the contractor's cost accountant at less than 40 ct. a cubic yard.

Mixing Plant and Other Equipment Used in Constructing Pavement.

The pavement was made 5 in. thick where laid directly on the dirt surface of the unpaved road, and a 2-in. surfacing was laid on the old macadam.

Method of Construction.—The mixing was done in a Cummer portable road asphalt paving plant, slightly modified, so that the mixing bucket was somewhat larger, to admit of the effervescence which takes place when the copper sulphate is added to the heated asphalt. The heated asphalt is delivered by force pump, the sand is handled by automatic conveyor, and delivery to truck is made automatically on completion to the mix by opening the bottom of the pug mixer. The material was loaded onto the trucks at about 320° F.

On this job, after the hot material had been spread, all rolling took place lengthwise of the highway, it being impossible to undertake the customary cross-rolling on account of the paving extending close to the side of the fill.

In the 5-in. section on dirt, as this thickness could not be rolled at a single operation, the job was done in two layers, a 3-in. base with a 2-in. covering.

View of Completed Pavement.

The 2-in. paving laid over an old macadam foundation was placed after the top of the old road had been scarified and a 12-ton roller used for leveling and scraping.

This paving was begun May 28 and completed July 1st. It was opened to traffic a few hours after completion.

Condition of the Pavement.—Since its completion, the pavement has received a daily pounding of the heavy traffic described above. This traffic is carried at the full rate of speed of the vehicle, and is continuous. The pavement is only 20 ft. wide, and as vehicles pass each other at very close intervals of time, the drivers practically follow in a track, so that wheel impact is not very much distributed over the surface.

This pavement has several times been subjected to extreme stresses of heavy combination truck and trailer loads. There has been a great deal of movement of lumber and also of other heavy commodities, mostly by truck and trailer, or truck and two trailers.

At the present time the pavement shows no signs whatever of any cracks and it has withstood the effects of traffic during the extreme summer heat of Southern California without rutting or waving. In fact, one of the claims made for Willite is that it sets so firmly that it is not affected by heat, the effect of the sulphate treatment being to lower the penetration of the completed pavement without increasing brittleness.

About 12 days after the completion of the work some slipping was noted between the upper and lower courses. An inspection showed that the failure to properly bond was due to dust which had drifted onto the completed lower course before the top 2-in. was applied. Accordingly, it was determined to remove as much of the 2-in. upper course as could be pried off with crowbars and resurface, first treating the exposed surface of the 3-in. base to insure bond by roughening with picks and applying a "paint coat," after which a new 2-in. surface was immediately spread and rolled.

Since the original completion of the job, there has been no indication of any separation from its base of the 2-in. surface laid over the old macadam foundation; nor has the relaid 2-in. top course in the 5-in. pavement shown any signs of trouble.

To insure perfect bonding the base course should not be laid far in advance of the 2-in. top and if the base remains exposed more than a short time it should be carefully examined and all foreign material removed.

Similar pavements constructed in Kingston, N. Y.; Brockton, Mass.; Bluffton, Ohio; Niagara Falls, Ont., and in a number of southern localities are in excellent condition, having required no maintenance whatsoever.

Contractors' Viewpoint of Highway Contracts

Until recently large contractors have not been particularly interested in highway construction. The reasons for this are set forth in a statement presented Dec. 8 at the annual convention of the American Association of State Highway Officials by the Highway Division of the Associated General Contractors of America. The statement, an abstract of which follows, also suggests the means by which large contracting concerns can be brought into highway work.

Contractors' Organizations.—The problem of carrying through the tremendous highway program which has been outlined depends even more upon the contractors' organization than it does upon material supplies. Materials will ultimately arrive at the job, but without the adequate organization to put them into place and to get the work done, no great advance over the high-water record of 1919 can be expected. Until very recently it has been an outstanding characteristic of highway construction that large contractors have not been particularly interested in highway contracts. Unless these men with their large organization and capital, with their adequate equipment and well organized force of men to handle big projects are encouraged to take part, and to find a share in that program attractive to them, large parts of work are bound to remain uncompleted.

To bring these men into the work the following suggestions are offered:

(1) Let contracts in longer sections in one contract extending over longer periods of time than one season; and have such contracts include all the work on any section including grading, paving, bridges, culverts, etc.

(2) Let contracts only to responsible contractors who will show the qualifications sufficient to perform the contract as stated, careful consideration being given to the contractors' organization, equipment, **past performance** and financial responsibility.

(3) Safeguard highway contracts from unnecessary risks, such as forced increases in freight rates, time lost bidding on jobs which do not go ahead, tying up of proposal guarantees and other losses incident upon delay in awarding contracts, unlimited responsibility on the part of contractors, unreasonable provisions of maintenance of highway after completion, retention of unnecessarily large percentages of payments, lack of specific information in plans and specifications and inadequate amount of time allowed for studying them, needless refinement insisted upon by inexperienced inspectors, etc., etc.

An Adequate Supply of Labor.—When the problem of attracting sufficient able contractors' organizations to undertake highway work is solved, the question of adequate labor supply will solve itself, for with better equipment and an able organization, forces of labor can be quickly brought together and utilized to greater efficiency. The right sort of contractors' organizations can also supply and keep the right kind of labor because they will maintain the right sort of conditions to keep good labor on the job.

Scope of Contract.—The chief reason which has deterred the majority of large contractors from undertaking highway work is the scope of the contract. Adequate equipment for highway construction undertaken on a scale which would be attractive to a large organization is too expensive an investment for a single season's contract on a small stretch of road.

In view of the unprecedented shortage of labor it is obvious that the construction program which has been outlined can be carried through only by substituting machinery for labor. When it is recognized that the special equipment necessary to construct 8 to 10 miles of concrete highway in one season will cost from $75,000 to $100,000, you will realize the enormous investment which will have to be made to carry out under existing conditions the program which the public demands.

These factors should be given great consideration in determining the scope of the contract and the fitness of the concern to whom the contract is to be awarded. If each contract were let in larger sections, extending over longer periods of time than a single season, larger contractors would find it worth while to devote their organizations and necessary equipment investment to large scale highway construction.

In this connection it seems almost unnecessary to point out the effect of the tendency in some states to let different parts of the work in the section to different contractors. Large contractors with large organizations are not interested in highway work where the grading is let to one man, the paving to another, and the bridge and culvert work to still others. He is equipped and organized to handle a job from start to finish, and his whole force is co-ordinated with that end in view. To engage one part of it only is to enforce idleness on the others and to disrupt his organization.

Again, the responsibility for co-ordinating his organization and work with that of other contractors frequently involves greater risks and losses in time and money than these contractors care to bother with. Especially is this true where there is a separation of such parts of the work as grading and paving. General contractors are organized to handle large contracts as a whole and if the advantage of their large scale organization is to be had in highway work, highway contracts must be let as a whole. The saving to the state in better highways and in greater mileage produced will more than offset the apparent saving which appears on paper in totaling up separate bids.

When the highway contracts are let under a general contract rather than in job lots, and in larger sections extending over a larger period of time than one season, more large contractors with their more efficient organizations and better equipment will be interested in highway construction. The result will be immediately evident in both the quantity and quality of mileage produced.

Recognizing Reliability in Awarding Contracts.—There is, however, a second consideration which has almost as great a bearing on the question of interesting large and able contractors' organizations in highway work and that is the elimination of the unreliable and irresponsible contractor as a factor of comparison in awarding contracts. Reliable and compent contractors will not waste time submitting bids in highway work when they realize that no consideration will be given to their organization, equipment, past performance, financial responsibility, and general ability to perform the contract. Of all types of construction, highway work offers greater possibilities for the "fly-by-night" contractor to compete on an apparently equal footing with the responsible man, than almost any other kind of construction.

The characteristics of public work enhance these possibilities. As a result, unless some of the obvious factors such as have been mentioned are given greater weight with the actual price figures, first-class men will not bid on highway work. How to work out this problem so that these factors will also appear as elements in determining the award of highway contracts must be left to you state highway officials. Some plan must be developed, however, for giving contractors assurance that those factors will be considered if the ablest men are to be attracted to highway work. Again, the obvious saving of a few dollars as between the low bidder who does not know his business and cannot perform the work satisfactorily and the contractor who knows his costs and guarantees an A-1 performance, in reality exists only on paper.

You get just what you pay for in highways as in anything else; and past experience has shown that a mile of highway let is an entirely different thing from a mile of highway built —and built well and in a reasonable time. It can be set down as fundamental that more mileage and better highways can be produced by better contractors, and better contractors will be interested in highways only when the quality which enables them to produce such results is given weight in comparison with men who can bid but cannot perform.

Eliminating Unnecessary Risks.—It is probable if contractors could be assured of contracts whose scope would interest large organizations and capital investment and a due recognition of quality and performance as well as bidding price, that the main obstacle to interesting large contractors in highway construction would be overcome. And if the larger contractors become interested in highway construction, the colossal program outlined will be carried through. But even then, highway construction would not be all smooth sailing. There exist at present in highway work, due to the fact that it has practically grown up overnight, various risks and undeveloped elements which make contracting in this field less attractive than in the more developed lines of construction. While individually these are of less importance, together they have a very important bearing on the interest which contractors with large and capable organizations take in highway work.

The procedure and practice surrounding the letting of highway work is in some states still in the stage of development. Proposals for highway work are frequently requested when the details of financing have not been taken care of. As a result, the letting is delayed if not indefinitely postponed, and the proposal guarantees held up, and time lost all around. Bids are rejected in highway work for any reason under the sun, and the contract let to someone else who will cut under the figures announced.

Sometimes plans are not delivered on the work to be let until a few days before bids are asked for, and then frequently the plans give only the most meagre information. On the other hand, needless refinements in the specifications are sometimes insisted upon by young and inexperienced inspectors when the progress of the work demands a reasonable interpretation. For example, the actual experience of responsible contractors who have tried to follow out the specifications in some highway contracts governing the use of dry mixtures in concrete pavement construction prove it to be absolutely impracticable to mix concrete as dry as the specifications demand. Again, the requirements for grading, if literally interpreted, make it necessary to figure on half an inch more of concrete in order to be on the safe side.

According to some contracts, the contractor's responsibility for all easements, or for the maintenance of the highway even after it is turned over to the public seems almost unlimited. At the same time the retained percentage on highway work is frequently away out of proportion to the actual necessity for safeguarding the state, to the serious inconvenience and loss on the part of the contractor.

In all these points, the contractor is not asking the highway departments to relieve him of the risks which he is paid to assume, but rather to relieve him of those risks for which he is not by any right responsible and which have given highway construction so bad a reputation.

Freight Rates.—One of the most obvious of these details which have served to keep conservative contractors away from road construction, is the uncertainty of freight rates. Fortunately some state highway departments have already made provision to allow for such increases in freight rates; but the majority have still to make adequate provisions for reimbursing the contractor for increases in freight rates which are ordered after he has signed his contract. Such a risk is one which no contractor can provide against and one which no highway department has a right to ask a contractor to assume.

Where bids are rejected due to difficulties in financing or for other good and sufficient reasons, the low bidders should be reimbursed at least one-half of one per cent of the average of their bids toward their expense.

Plans and Specifications.—In order to secure responsible contractors who will make responsible bids on highway work, time to make up an intelligent bid must be allowed. A reasonable length of time, say three weeks, can be established as the minimum time between the date plans and specifications are furnished and the date bids are to be submitted.

It is surely not an unreasonable request also to ask that plans and specifications show the limits of the right of way, the amount of grading to be done, the location of culverts, bridges, etc., and the sizes of these with a reasonable amount of accuracy. Furthermore, it seems reasonable also to suggest that if there are any material changes in the plans furnished to the contractor after the contract is awarded, that the contractor be compensated for the extra cost and delay on account of making such changes. Such suggestions as these provide no special favors for the contractor; they are simply checks which properly safeguard the contractor against loss of time and money due to lack of reasonable consideration for his interests on the part of the officials in charge of the work.

If refinements in specifications are shown to be unreasonable, joint consideration by contractors and engineers in conferences like this should remove them. Inexperienced inspectors are frequently placed on highway work, and both contractors and engineers should urge the proper authorities to appropriate sufficient funds to secure the services of competent men by paying them a wage equal to that paid the same class of men in other industries.

Limiting the Contractor's Responsibility.—We do not think it unreasonable to ask that the contractor's responsibility and liability be limited in several respects on highway work, and we believe that to do so will help encourage responsible contractors to undertake highway work. The practice adopted in some states of providing easements to contractors for special roads and bypaths maintained for public convenience might be adopted to advantage by other highway departments. Again, to ask contractors to be responsible for the maintenance of roads after they have been opened to public use is to make them responsible for the plans, specifications and inspection which it is the highway department's duty to assume.

If the plans and specifications are sufficient to get a satisfactory road, and if the inspection is properly done, it can be rightly assumed that a good road has been constructed. To extend the contractor's responsibility, as in some states, to a year after the completion is sufficient to drive any reasonable contractor from highway construction. Each section of highway work as it is opened for public use shuld be accepted at the time and paid for in full.

Payments.—The question of payments, beginning with the return of the proposal guarantee and including the payment for work done, is a problem which warrants more consideration if highway contracts are to be developed to their greatest efficiency. The recent clause adopted in Minnesota solves some of these difficulties. According to its provisions, all contracts are to be awarded within ten days after the date of the proposal, and all proposal guarantees, except that of the successful bidder, will be returned within three days following the award of the contract. Should no award be made within ten days, all proposals will be rejected and all guarantees returned.

Again, in making progress payments on work, we believe that monthly or semi-monthly estimates should be based on 100 per cent of the work done, with a sufficient percentage retained to protect the owner. This retained percentage should never exceed 10 per cent and should stop when it amounts to 5 per cent of the total estimated amount of the contract. Large contracts soon run into big money and partial payments based on estimates that are reduced at every step as they go down the line, and retained percentages which exceed reasonable limits, soon find the contractor with large investments, not only in organization and equipment but also in state highways—perhaps the last place in the world he wants it invested.

The engineer corps of the U. S. Army follows such a plan with reference to retained percentages on its work and finds it very satisfactory. Similarly, the same plan may be applied to the reduction of the amount of bond necessary as the work is completed.

Force Account Work.—Payment for force account work frequently is a cause of friction in highway work. The clause recently adopted by the State Highway Department of Minnesota is worth consideration in this connection. Paragraph 33 of the Minnesota Specifications entitled "Force Account Work" has been changed to read as follows:

> All work done on Force Account basis will be paid for in the following manner:
>
> (a) For all labor, teams and foremen in direct charge of the specific operation, and such other expense as is directly a part of the cost of the work, the contractor shall receive the current local rate of wage, to be agreed upon in writing before starting such work, for each and every hour that said labor, teams and foremen are actually engaged in such work, to which shall be added an amount equal to 15 per cent of the sum thereof.
>
> (b) For all materials used the contractor shall receive the actual cost of such material, including freight charges as shown by original receipted bills, to which cost shall be added a sum equal to 15 per cent thereof.
>
> (c) For any machine, power, tools or equipment, including fuel, lubricants, which may be deemed desirable or necessary to use, the engineer shall allow the contractor a reasonable rental price, to be agreed upon in writing before such work is done, for each and every hour that said tools or equipment are in use on such work, to which sum no precentage shall be added.

Engineer's Estimates.—With the question of payments is closely connected the subject of the engineer's estimate. When highway contracts are let at unit prices, the engineer directly in charge of the work feels, nevertheless, that the total cost should correspond as nearly as possible with the costs shown on his original estimates. While both contractors and engineers recognize the fact that it is almost impossible to prepare plans and specifications that are so perfect that they do not have to be altered after the work is started, thus affecting the original estimate, county boards and other officials who are not experienced in engineering and contracting, are not so ready to acknowledge the engineer's estimate as an approximate figure. In making adjustments on cost plus work frequently the result is that basing his stand on this estimate, the local engineer attempts to make a lump sum contract out of a unit price job. State highway officials can do much toward educating local engineers in regard to this subject, and help secure much more reasonable consideration of work done on a cost plus basis. To do so will help remove another of the causes which keep contractors out of highway construction.

Marking and Signing a State Highway System

Under the legislation providing that the state trunk line system of Michigan previously established by law should be "improved, constructed and maintained under the direction, supervision and control of the State Highway Commissioner," he also was instructed to "cause all state trunk line routes to be distinctly marked by signs and guide posts of a uniform design as may be deemed necessary for the public convenience and necessity," and "to cause to be published a map of the State of Michigan showing thereon the state and county road system.' Provision was also made for numbering the routes and showing the corresponding numbers on the roads shown on the maps. The system adopted was discribed by Mr. L. H. Neilsen, Deputy State Highway Commissioner of Michigan, in a paper presented at the recent 5th annual meeting of the American Association of State Highway Officials, from which the matter following is abstracted.

Following out the provisions of this legislation several designs were considered with the result that a standard design was agreed upon consisting of a diamond 15 in. in length and 13½ in. wide. Across the middle will appear the words "State Trunk Line" with a block "M" above and the numbers of the route shown below. For the markers to be used on telephone and telegraph poles a black letter on a white background will be used. This will also apply to markers placed on buildings and suitable natural objects along the roadside. For this preliminary marking, stencils and county maps showing the roads to be numbered in each county have been prepared and instructions to the county authorities made ready to send out.

These markers will be placed on telegraph and telephone poles when they are available, both sides of each intersecting cross-roads with an occasional one in between. 300 to 600 ft. before a turn in the road is reached, the white band will be widened and an "R" or "L" as the case may be, shown below the standard marker. Where a pole is not available and no buildings or natural objects will answer the purpose, cedar posts will be set up and the marker placed on them.

Standard railroad crossing signs will be shown about 600 ft. from all grade crossings. Dangerous curves will also be marked.

Although it is not the intention to maintain that portion of the routes lying within incorporated cities and villages previously paved, it is very necessary that it be plainly marked through every village and city. It is the intention to place direction signs at the intersection of the routes with improved roads showing distances to the nearest town.

For the present no marking of the county road system is planned although it is expected that a standard design for marking them will be decided upon within another year. The marking so far referred to is primarily intended for the guidance and information of the traveling public. In order to make this information most valuable, the map referred to must be provided and made available to the public. Because of the shape of the state, it was thought advisable to issue two separate folders, one showing the routes in the Upper Peninsula and the other those in the Lower Peninsula. This map is now being published and will be available for distribution by the time it will be possible to do the marking which will be early this year.

In addition to this marking it is proposed to place mile markers on all the routes. Locations for these will be determined from automobile's speedometer readings. These mile markers will consist of plack diamond shape boards. with a white moulding border and the standard lettering in white. These will be set on angle iron posts. The posts will be numbered from the south to the north and from the east to the west.

At the same time that the location of the posts is determined a variety of information can be gathered and compiled for future use.

Maintenance Cost of Water Bound Macadam at Hartford, Conn.

Interesting data on the maintenance of waterbound macadam streets at Hartford, Conn., were given by Mr. Leon F. Peck, Superintendent of Streets of that city, in a lecture delivered Jan. 9 before the post-graduate students in civil engineering at Yale University. The matter following is abstracted from the address.

Waterbound macadam comprises 73 per cent of the streets of all kinds, paved and unpaved, in the city of Hartford. The macadam maintained over the 10 fiscal years 1907 to 1916, inclusive, averaged 97 miles per year. In area this amounted to 1,321,000 sq. yd. per year. Probably 50 per cent of these streets have been macadamized more than 20 years. Over most of this 10-year period, labor cost 25 ct. per hour, and a team with driver 62½ ct. per hour.

	Per sq. yd. per year.
Average cost for the 10 years of maintenance, including restoration or renewals	$0.0343
Cost of depreciation at 10 per cent and interest at 4½ per cent on $13,400 worth of equipment	0.0015
Total, including depreciation and interest, averaged over the entire macadam area	$0.0358

The average annual cost, not including interest and depreciation for the first three years of this 10-year period, was $0.0340 per square yard, for the middle four years $0.0365 per square yard, and for the last three years $0.0317 per square yard.

Thus it is seen that the direct cost of maintenance did not increase during the 10 years notwithstanding the great increase in the number of motor vehicles.

During the next three years the cost of labor, teams and materials increased until the rates for the fiscal year ending March 31, 1919, stood as follows:

Labor, 37½ ct. per hour, an increase of 50 per cent

Teams with drivers, 87½ ct. per hour, an increase of 40 per cent.

Repair materials increased about 40 per cent.

The actual cost for that year of maintaining 107 miles of macadam or 1,416,000 sq. yd. was $0.0551 per square yard, an increase of 60 per cent over the average for the 10-year period. This percentage of increase is in excess of that for labor and materials. It is believed that the excess is entirely due to the fact that war restrictions prevented the securing of the customary amount of asphaltic road oil, thus the usual maintenance benefit of the oil was lost.

Taking the present cost of new macadam at Hartford, which is 99 ct. per square yard and distributing it over a period of years long enough to bring in the average maintenance costs, say 20 years, then the ultimate cost can be determined as follows:

Interest at 4½ per cent on first cost for 20 years = $0.045 × $0.99 × 20, per sq. yd.	$0.8910
Sinking fund to repay original outlay at end of 20 years, compounded annually at 4 per cent = $0.03358 × $0.99 × 20	.6649
Present annual cost of maintenance, including depreciation and interest, $0.0566 per square yard, for 20 years, $0.0566 × 20 =	1.1320
Ultimate cost per square yard for 20 years	$2.6879
Ultimate cost of Hartford's macadam per square yard per year	0.1344

Labor Organization and Cost of Constructing Federal Aid Concrete Pavement in Colorado

Colorado Federal Aid Project No. 1 comprised the construction of a concrete pavement on the Denver-Littleton road. The pavement was a 1:2:3 mix, 16 ft. wide, and 5½ in. thick at sides, and 6½ in. thick at the center. The total number of square yards was 36,974 which required the placing of 6,325 cu. yd. of concrete giving a ratio of 1 cu. yd. to 5.85 sq. yd. of pavement. The work was done by contract. It was commenced in July, 1918, and finished in November of that year.

The mixing was done in a No. 514 Smith Chicago paver with rotary distributor. The size of batch was 3½ bags. This mixer had been in use for 7 years. The side forms were wood, and they were used over again.

The fine grading and preparation of subgrade were very poor, and this occasioned delays in front of the mixer. The concrete pavement work was delayed considerably owing to lack of facilities for furnishing materials fast enough to keep the mixer in continuous operation.

Rear View of Mixer and Gang, Showing Two Sets of Wheelers on Gravel and One on Sand.

Common labor and teamsters were paid $4 to $4.50 per 9-hour day. Team and driver were paid at the rate of $7 per day. The average haul on cement was ¾ mile; on sand ¾ mile, and on gravel ⅞ mile.

The size of the concrete gang was dependent, to a great extent, on the ability of the contractor to get and keep enough laborers to carry on the work. From the beginning of the pavement work on July 19 to the last of August, the concrete gang was made up as follows, and the following scale of wages prevailed per 9-hour day:

	Per day.
1 foreman	$ 7.00
1 mixer operator (attends to firing)	6.00
1 man regulating water for batch and dumping mixer	4.00
1 boy on revolving distributor spreading concrete and wetting subgrade	3.75
1 man spreading concrete and assisting installing joints	4.25
2 men on strike board, striking off and tamping concrete, at $4.00	8.00
1 finisher, rolling, belting, hand floating and edging	6.00
1 man shaking out and bundling cement sacks; also assisting finisher to belt concrete and move bridge	4.00
2 grade men around mixer leveling up subgrade and tamping where necessary, at $4.00	8.00
2 men moving and setting forms also installing joint material, at $4.00	8.00
2 men carrying and putting cement into mixer hopper, at $4.00	8.00
2 men on mixer hopper assisting in dumping wheelbarrows, moving mixer runways, and taking care of hose from pipe line to mixer, at $3.75	7.50
6 men on two sets of gravel wheelbarrows, loading and wheeling, at $4.25	25 50
2 men on one set of sand wheelbarrows, loading and wheeling, at $4.25	8.50
2 extra men loading gravel in wheelbarrows, at $3.75	7.50
1 extra man loading sand in wheelbarrows	3.75
3 men covering and wetting concrete, at $3.75	11.25
1 water boy	1.50
1 night watchman, wetting concrete and taking care of fire on mixer	4.00
33 men. Total	$136.50

The average daily run of this gang, when material was on hand, was 480 lin. ft. of pavement per day, the maximum run being 70 lin. ft., the above runs being equivalent to the placing of 146 and 173 cu. yd. of concrete.

From the first part of September to the end of the work on Nov. 5, the concrete gang was smaller, averaging about 25 men, and differed from the above organization as follows:

The man spreading concrete was eliminated, his work being done by the strike board men, who were advanced to $5 per day.

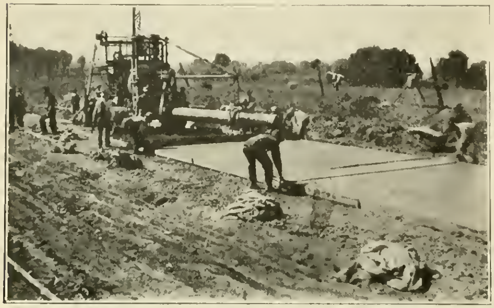
Where two men had previously been used, one man was now used on each of the following: grading in front of the mixer, handling cement to material hopper, and moving and setting forms. These men were advanced 50 ct. to $1 per day. The men used for covering up were eliminated, as this work was performed each morning by the whole gang before any concrete was laid. One of the extra men loading wheelbarrows was also eliminated, and the pay of the wheelbarrow men was raised to $4.50 per day.

The total wages per day for these 25 men were $112.50, and the average and maximum daily runs were 420 and 505 lin. ft. of pavement, this being equivalent to the placing of 128 and 154 cu. yd. of concrete. This gang had the maximum weekly run of 2,370 lin. ft. of pavement, which was accomplished in 5½ working days.

The organization of the concrete gang was very good, and the work went along very smoothly, the only serious trouble being the lack of materials.

The following table shows the cost of the pavement:

Labor:	Cost Per cu. yd. Concrete.
Supervision (foreman and timekeeper)	$0.175
Preparation of subgrade for concrete	.059
Setting and moving forms	.066
Loading, mixing, placing and finishing	.994
Covering, cleaning off, cutting joints	.095
Pipe line, hauling, laying and removing	.063
Assembling and dismantling mixer	.012
Mixer—to and from job—Denver	.010
Total labor	$1.472



Front View of Mixer, Showing Operations of Striking Off and Belting Surface.

Concrete Materials:	
Cement—	Per bbl.
F. o. b. mill	$1.98
Freight	.32
Loading, hauling and unloading	.15
Freight return bags and losses	.05
Total cost per barrel	$2.50
Cost per cu. yd. concrete (1.70 bbl.)	4.25

Roller Removing Excess Water from Surface of Pavement.

Sand—	per cu. yd.
Average cost screened in piles or at pit	$1.00
*Loading and hauling to road	.50
Cost per cubic yard	$1.50
Cost per cu. yd. concrete (0.60 cu. yd., which allows for waste)	.90

Belting Last Block of Day's Run of 570 Lin. Ft.

Gravel—	
Average cost screened in piles or at pit	$1.20
*Loading and hauling to road	.60
Cost per cubic yard	$1.80
Cost per cu. yd. concrete (0.80 cu. yd., which allows for waste)	1.44
Total cost cement, sand and gravel per cu. yd. concrete	$6.59
Water—From Denver and Littleton water mains	$0.06
Joints—Carey's Elastite, ¼ in. premoulded asphalt	.065

*Loading and hauling combined, as drivers helped load materials.

Materials and Repairs:		Cost per cu. yd. concrete.
Mixer—		
Coal, price $8.00 per ton		$0.051
Oil, waste and packing		.006
Repair parts		.012
Total mixer		$0.069
Side Forms—Lumber and pins		.016
Total cost of materials and repairs		$0.085
Interest and Depreciation:		
Mixer, $2,300.00, at 15%	$345.00	$0.055
Pipe line and connections, $750, at 15%	112.50	.018
Small tools hose, etc., $140, at 50%	70.00	.011
Total interest and depreciation		$0.084

SUMMARY OF COST

	Per Cu. Yd. Concrete in Road.
Labor	$1.472
Cement	4.250
Sand	.900
Gravel	1.440
Water	.060
Joints	.065
Materials and repairs for plant	.069
Side forms	.016
Interest and depreciation on plant	.084
Total per cu. yd. concrete	8.356
Total cost of concrete pavement per cu. yd	$8.356
Total cost of concrete pavement per sq. yd	$1.427

The road was built under the supervision of Mr. Clyde E. Learned, Senior Highway Engineer, U. S. Bureau of Public Roads, to whom we are indebted for the information given here.

Snow Removal Method for Cities of About 200,000 Population

Interesting information on snow removal methods adapted to conditions usually prevailing in cities having a population of not more than 200,000 was given by Mr. Leon F. Peck, Superintendent of Streets, of Hartford, Conn., in a lecture delivered Jan. 9, to the post graduate students in civil engineering at Yale University. The matter following is abstracted from the lecture.

Two methods of undertaking the work have been employed: First, wait until the storm has nearly or wholly ceased; second, begin work of removal practically as soon as snow begins to fall.

It has been customary in cities of this class to adopt the first method. There is now, however, a tendency to adopt the second.

The first method was practically necessary for north latitudes of about 42 degrees, on account of the large amount of business done with sleighs or sleds; but where motors are gradually being substituted for horses the need of leaving snow for sleighs lessens.

If the storm is prolonged the work should start anyway when about 8 in. have fallen. This will mean going over the ground again after the walks have finally been cleared, but there will be so much less snow to remove therefore valuable time gained.

The second method "beginning work immediately" has its place in certain business districts. With this method where sewers of suitable size are available and openings sufficiently close the snow may be scraped directly to the sewer. If conditions are such as to make this method impractical, motor or horse drawn snow scrapers will pile the snow in ridges to be later hauled away. Hand piling is expensive. Most of the ridges can be hauled away soon enough to avoid this expense. Previous to the world war the labor conditions during the winter months usually were such as to make it possible to secure men for snow removal at the rate of about 2½ to 4 per 1,000 population. The number available under present conditions remains to be determined. It surely is less.

Practically all snow removed has been shovelled by hand into trucks or street railway freight cars and hauled to the nearest dumping place which may be a vacant lot, a water front, or a sewer manhole. Smaller cities are not to any extent removing snow as it falls by scraping it into the sewer manholes. A number of cities are dumping snow from trucks through the manholes into large trunk or intercepting sewers, but are sceptical about using the smaller sewers, some having previously had trouble from this source of disposal.

Assuming the proportionate number of teams and men available as previously given, we have (exclusive of the regular street cleaning force) approximately 25 men and 15 teams for each mile of streets from which it is customary to remove snow. With the customary short hauls such a force could take care of a heavy fall for from 25 ct. to 50 ct. per cubic yard, and in a manner generally satisfactory in cities of less than 200,000 population.

The maximum snow expenditure for a winter in any of these cities rarely exceeds $40,000.

Experience indicates that the following methods or rules can be recommended:

Emergency work should be done under direct control of the city on a day labor basis, rather than by contract.

Teams and trucks secured by telephone or messenger from list of owners on file.

Extra men secured through the regular street cleaners who should be trained by the foremen to send all the men they can to force organizing headquarters whenever their experience tells them that extra men are needed.

Emergency foremen should be selected from the list of regular city foremen and inspectors of repairs, road construction, grading, street sprinkling, street lighting, forestry, etc., who are all or in part usually (in cities of this class) under the one street department responsible for snow removal.

The city's first aid should be directed towards the principal congested center and toward opening up fire department streets to the railway track streets.

There is little or no financial advantage gained in attempts to use sewers for snow disposal if water fronts and vacant lots are available at practically no greater haul.

Cities making long hauls and having sewers 18 in. or more in diameter in snow removal sections should surely give the method a trial with the aid of a hydrant stream if necessary. Economy snow removers, so called, which are simply a large horse drawn scoop can be used on short hauls.

Special openings provided in the floor of bridges are good if the haul can be shortened thereby and the traffic is not too congested for such a provision.

Road scrapers, either horse-drawn or motor-driven, can be used in clearing pavements, opening gutters, or in piling snow in ridges for removal or in leveling ridges for sleighing.

All surplus snow thrown from the tracks of street railways should be leveled and pushed toward the curb by the company, using a 14 to 16 ft. spreader board 3 ft. high attached to the snow plow and adjustable at any angle.

Gondola or other types of freight cars can be used on the street railway tracks for hauling snow after midnight, and in some cases can be used during the day by closing a few blocks to street railway passenger traffic if the cars can be sent around the closed blocks on the next parallel street.

Cooperation of city departments is important.

Illinois Short Course in Highway Engineering.—The 7th annual short course in highway engineering of the University of Illinois will be given at Urbana, Feb. 16 to 20. C. C. Wiley, assistant professor of highway engineering, is in general charge. The annual short course in highway engineering is given for the county superintendents of highways, practising highway engineers, county and township road officials, and contractors engaged in road and pavement work. This year special sections and addresses are offered for city engineers and city managers. The State Division of Highways is cooperating in this work and in addition will meet the county superintendents of highways in an administrative meeting at Springfield on Feb. 12, 13 and 14.

West Virginia Road School.—The State Road Commission and West Virginia University will hold a good roads school Feb. 17 to 28 inclusive. The first three days will be devoted to a conference of county officials, county engineers and the state road commission. Following this there will be an 8-day intensive course for highway inspectors. The instructing staff will consist for the most part of division engineers of the state road commission assisted by the civil engineering faculty of West Virginia University.

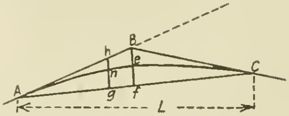
Instructions and Table for Reducing Labor in Curve Computation

By J. A. LILLY,

Resident Engineer, Ohio State Highway Department.

Probably most of us who have to use vertical curves in highway or railroad work have become wearied, impatient and vexed by the tedious computations required to determine the elevations of grade points on the curves.

In order to reduce the time and labor of computations to a minimum, the writer, after examining various formulas, prepared the following instructions and table which have proved to be very useful.



The curve AeC is a parabola, tangent to the grade lines AB and BC at A and C respectively.

Draw AC. Draw Bf bisecting AC and intersecting the curve at the middle point e.

Call Be (the middle ordinate) M.

Let L be the length of the curve, = AC.

Let r be the rise or fall per foot of AB, and r′ the rise or fall per foot of BC; ascending grades being considered + and descending grades —.

Let n be any point on the curve between A and C; hn the vertical distance of n from the grade line tangent AB (prolonged if necessary) and Ag the horizontal distance of n from A.

Since the curve is a parabola it can be shown that

(1) $Be = ef$, or $Bf = 2M$.

$$(2)\quad L = \frac{8M}{r - r'}$$

$$(3)\quad M = \frac{L(r - r')}{8}$$

(4) $Be : (Af)^2 :: hn : (Ag)^2$, from which, since $Be = M$ and $Af = \frac{1}{2}L$,

$$(5)\quad hn = (Ag)^2 \frac{M}{(\frac{1}{2}L)^2}$$

Assume a value for M and find the corresponding value of L from (2) or assume a value for L and find the corresponding value of M from (3). Having found the values of L and M the value of the ratio $\frac{M}{(\frac{1}{2}L)^2}$ can be found. Call this ratio R.

TABLE FOR USE IN SELECTING CURVES

L = 100'. R = .005(r − r'). R varies inversely as L.									
r-r'	M	r-r'	M	r-r'	M	r-r'	M	r-r'	M
.010	0.1250	.038	0.4750	.066	0.8250	.094	1.1750	.122	1.5250
.011	0.1375	.039	0.4875	.067	0.8375	.095	1.1875	.121	1.5375
.012	0.1500	.040	0.5000	.068	0.8500	.096	1.2000	.124	1.5500
.013	0.1625	.041	0.5125	.069	0.8625	.097	1.2150	.125	1.5625
.014	0.1750	.042	0.5250	0070	0.8750	.098	1.1150	.126	1.5750
.015	0.1875	.043	0.5375	.071	0.8875	.099	1.2375	.127	1.5875
.016	0.2000	.044	0.5500	.072	0.9000	.100	1.2500	.128	1.6000
.017	0.2125	.045	0.5625	.073	0.9125	.101	1.2625	.129	1.6125
.018	0.2250	.046	0.5750	.074	0.9250	.102	1.2750	.130	1.6250
.019	0.2375	.047	0.5675	.075	0.9375	.103	1.2875	.131	1.6375
.020	0.2500	.048	0.6000	.076	0.9500	.104	1.3000	.132	1.6500
.021	0.2625	.049	0.6125	.077	0.9625	.105	1.3125	.133	1.6625
.022	0.2750	.050	0.6250	.078	0.9750	.106	1.3250	.134	1.6750
.023	0.2875	.051	0.6375	.079	0.9825	.107	1.3375	.135	1.6875
.024	0.3000	.052	0.6500	.080	1.0000	.108	1.3500	.136	1.6900
.025	0.3125	.053	0.6625	.081	1.0125	.109	1.3625	.137	1.7025
.026	0.3250	.054	0.6750	.082	1.0250	.110	1.3750	.138	1.7150
.027	0.3375	.055	0.6875	.083	1.0375	.111	1.3875	Prop. Parts.	
.028	0.3500	.056	0.7000	.064	1.0500	.112	1.4000	.0001	00125
.029	0.3625	.057	0.7125	.065	1.0625	.113	1.4125	.0002	00250
.030	0.3750	.058	0.7250	.066	1.0750	.114	1.4250	.0003	00375
.031	0.3875	.059	0.7375	.087	1.0875	.115	1.4375	.0004	00500
.032	0.4000	.060	0.7500	.088	1.1000	.116	1.4500	.0005	00625
.033	0.4125	.061	0.7625	.089	1.1125	.117	1.4625	.0006	00750
.034	0.4250	.062	0.7750	.090	1.1250	.118	1.4750	.0007	00875
.035	0.4375	.063	0.7875	.091	1.1375	.119	1.4875	.0008	21000
.038	0.4500	.064	0.8000	.092	1.1500	.120	1.5000	.0009	01125
.037	0.4625	.065	0.8125	.093	1.1625	.121	1.5125		JAL

The vertical distance from any point on the curve to the grade line tangent AB (prolonged if necessary) will be R times the square of the horizontal distance of the point from A.

The accompanying table will be found useful in selecting curves. This table gives the value of M for a curve 100 ft. long with varying values of $r - r'$. Since M varies directly as L the value of M for any other length of curve can be found by comparing with M for a curve 100 ft. long.

By working out the value of R in a few examples it will be observed that for a curve 100 ft. long $R = .005 \times (r - r')$. By substituting the value of M in (5) it will be seen that R varies inversely as L.

Example: $r = +.012$; $r' = -.034$; $L = 230$ then $r - r' = +.046$. M for curve 100 ft. long $= .575$; M for curve 230 ft. long $= .575 \times 2.3 = 1.3225$.

R for curve 100 ft. long $.005 \times .046 = .00023$. R for curve 230 ft. long $= .00023$ divided by $2.3 = .0001$.

Review of Highway Construction Conditions in Middle Atlantic States

Labor and material shortages and bad weather conditions were primarily responsible for the failure to complete but 40 per cent of the 1919 highway construction program in the Middle Atlantic States, according to a review of the work in these states by Mr. Samuel Knopf, Assistant Engineer Delaware State Highway Department, presented Dec. 9 at the 5th annual meeting of the American Association of State Highway Officials. An abstract of Mr. Knopf's report follows:

Reports from the highway departments of the Middle Atlantic States, comprising New York, New Jersey, Pennsylvania and Maryland, indicate a total mileage of highways under construction during the calendar year 1919 of approximately 1,900 miles. The moneys expended to carry on this work amounts to nearly $75,000,000.

Labor Conditions Were Never More Unsatisfactory. It was first thought labor would be plentiful. The army was fast being demobilized and propaganda was spread broadcast that the soldier be first employed on all kinds of work. As the returned soldier did not take kindly to road work, labor obtained to carry on road work in this district was recruited largely from former munition workers. Accustomed to a higher rate of pay during the war, they became restless when they were obliged to accept wages averaging 45 ct. per hour. Their war savings made regular employment unnecessary. In certain districts of Pennsylvania, New Jersey and New York, there was a large exodus to Europe of the labor usually engaged on this kind of work. Contractors and others engaged on road work did not anticipate this instability of labor. In some localities there was not sufficient labor to carry on road work under construction and the other business of the vicinity. An actual shortage existed. In other localities, labor was plentiful, but disinclined to work regularly. As the season progressed labor became more unreliable. Some contractors imported labor from cities 75 miles distant. As an instance one job 2½ miles long, requiring an outfit of 50 men, which was completed in about three months, and examination of the payroll showed it to contain at least 500 different names. This labor turnover, besides delaying the progress of the work, influenced bidding prices and quality of workmanship.

Actual Shortage of Materials Existed.—Plants supplying materials were confronted with a large production program; larger than they had anticipated. With no chance to provide additional equipment; with labor uncertain in other lines; with present equipment in bad shape due to wear and tear of war work; they could not keep up production. Part of the time this was due to lack of transportation facilities, but, generally speaking, to an actual shortage, or to the fact that the territory was, so to speak, "overjobbed."

Equipment for transportation was in bad shape. Under Federal control, this had suffered considerably during the war, at which time, no noticeable improvements were made, because of a shortage of materials and labor, and the lack of needed appropriations. With the tenure of Federal control limited, and the country doing more business than ever before, the shortage of equipment has detailed great difficulties. Even now, there is a distinct shortage of cars for the movement of coal, grain and other commodities, which are being given first preference when any emergency arises. This condition became so acute during the last few months of the working season, that it almost put a stop to the construction program.

Bad Weather Conditions Seriously Handicapped Work.—The Middle Atlantic states experienced a poor working season during the bad weather. The number of working days actually fit for roadway operations averaged but 60 per cent of what is usually a fair average during a working season. Although this bad weather held back the road program it also helped to tide over the material shortage and made the material situation seem better than it actually was.

The lateness and hesitancy of awarding some of the contracts naturally delayed the program. Contractors looking for prospective work, marked time, and did not arrange for needed plant. Consequently, equipment orders piled up as the season progressed and deliveries came too late for the working season.

That all these factors have had an influence in the bids submitted for road work let out late in the season, is shown by the fact that in some instances these bids received ranged 10 per cent and 15 per cent higher than those submitted earlier, when every indication then pointed to "straight sailing" road building.

New Highway Laws Passed by State Legislatures.—During the year, legislation affecting highways was passed in several of the states. These laws affected the weights and tonnage carried by motor trucks and the use of traction engines on improved highways. Their use upon improved types of roads have been restricted. New legislation, empowering the highway commissioner to acquire land containing stone for road building purposes, has been passed in Pennsylvania. This stone may be used by the state or furnished and sold to contractors engaged on highway contracts under the state's jurisdiction.

Financing State Highway Work.—The magnitude of the highway program did not become apparent until the early part of 1919, when the state and county governments began to make provisions for road funds to an extent before unknown.

Besides the annual revenue derived by taxation for road purposes, bond issues authorized or pending, and other sources of money in the states were as follows:

PENNSYLVANIA—$50,000,000 in state bond issues, $17,000,000 in county bond issues authorized and $8,500,000 in county bond issues proposed.

NEW JERSEY—$5,000,000 in state bond issues, $1,000,000 in county bond issues authorized and $4,500,000 in county bond issues pending.

NEW YORK—$12,000,000 of the bond issue of 1912 and county bond issues approximately $7,500,000 authorized, within a proposed state bond issue to be introduced to the legislature for $100,000,000.

DELAWARE—$2,000,000 in state bond issues, $1,750,000 county bond issues authorized and $1,500,000 private fund.

MARYLAND—No state bonds have been passed or pending, this road program being carried on by legislative appropriation.

To these amounts of money must be added the considerable increase of funds available under the Federal Aid Act and the Post Office Appropriations Act, which provided an additional appropriation for Federal co-operation in the improvement of rural post and forest roads during 1919, 1920 and 1921. The money allotted to the states under these acts, amounts to $32,400,000, of which $5,500,000 was applied to road building during 1919.

The 1920 Construction Program.—Notwithstanding the fact that last year's road building program has been a disappointment, preparation for road building for 1920 is even larger than that undertaken this year.

The program calls for the construction of about 2,100 miles of hard surfaced highways, at an expenditure in the neighborhood of $100,000,000. Just what amount of this will be completed is problematical. Funds will not be the limiting factor. The limiting factors will be the same as those which held back this year's construction, namely, the amount of labor and materials available, including the ability of getting the materials on the ground and the lack of experienced and fully equipped contractors' organizations.

The program to be carried out requires the moving of 11,-

500,000 tons of aggregates, which includes the tonnage required to complete the projects carried over from last year's work. To this also must be added the tonnage of aggregates required in the resumption of building operations, railroad improvements, street work, maintenance of roads, etc., which has been seriously curtailed during the war and the year of 1919 waiting for a decrease in prices. Realizing that no decrease in prices is probable, and, because of the urgent demand for these improvements, it is safe to predict that they will be made.

To successfully meet this tremendous demand for materials, transportation facilities must be improved; plant capacities enlarged and productions increased. Each is supplementary to the other. The development of one, without the corresponding development of the others, would tend to increase rather than to minimize a difficult situation.

The fact that material producers were unable to secure transportation for their capacity production last year, has led them to curtail their output as a means of self protection.

Labor Condition at a Critical Stage.—There is nothing in the present situation to indicate that labor will be more efficient or more willing to work this year than it was last year, and, unless there is a full resumption of united effort, there is no chance for a larger production. Not until labor realizes that it is no longer engaged in war work, that no war profits and war wages exist in honest road building, will there be any change in the shiftless, unreliable work performed last year. Any tendency to increase their wages, as was done in some instances, seemed to decrease their efficiency. Contractors, to meet this kind of work, have turned to labor saving machines and it is safe to predict that these devices will be used where possible.

Industrial managers and concerns have begun to realize that to cope with this crisis, more efficient co-operation between all parties is necessary. It is apparent that there must be the greatest degree of co-operation between the contractors and the highway departments, material producers and the railroads, if delivery of materials to carry on this huge construction program is to be possible. Labor for the road work and existing transportation facilities must be employed in the most efficient manner.

Early Letting of Contracts.—To this end, the highway departments have issued prospectuses of this year's work. It is thought by this early announcement of the construction program that contractors will be given full opportunity to look over the roads, locate sources of materials, investigate terminals, etc. They will then be in a position to assemble plant and materials on the work, make financial and preliminary arrangements in advance of actual operations and make it more nearly possible to complete a majority of the contracts one working season.

Several highway departments also have carried on extensive material surveys and propaganda campaigns for the establishment of small local material plants, as well as securing available local supplies for contractors with crushing equipment.

Pennsylvania, as noted previously, has empowered its highway commissioner to purchase and acquire lands containing stone suitable for highway purposes; to purchase machinery and equipment to operate such quarries; and to use such stone for their own highways; besides power to sell, furnish and supply stone to contractors engaged in building or maintaining roads under the department's jurisdiction.

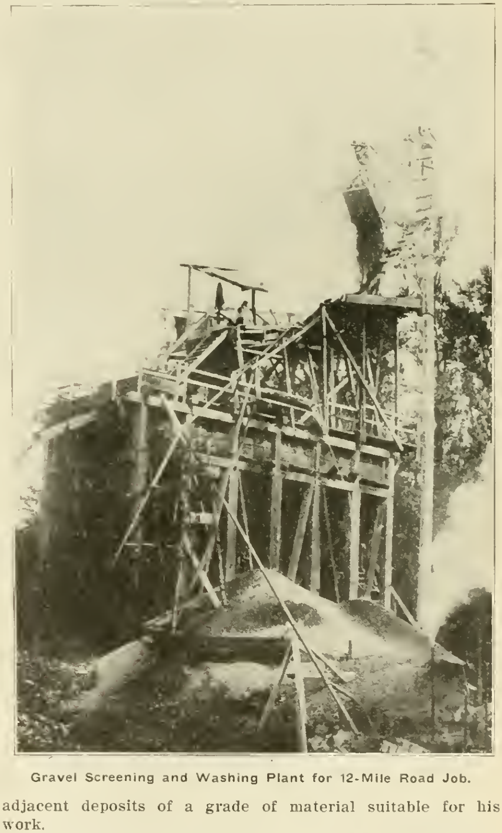
If possible, material estimates should be allowed. To arrange for early and regular deliveries of materials in advance of actual operations, is a considerable financial burden to a contractor, unless material estimates are allowed. Delaware's highway department, organized during the war year of 1917, found it difficult to secure bids on her road work. With the announcement that substantial materials estimates would be allowed, her entire program was put under construction. Materials estimates are still allowed and during the past season when shipments were "spotty" and irregular, enough materials were on hand to tide them over, causing no delay in the work. The result has been an increase in mileage, made possible by the allowance of these materials estimates.

Contractors can assist by perfecting adequate organizations and employing labor saving machines to replace some of their labor. Wonderful strides have been made during the past few years in these labor saving devices used in road building, such as central proportioning plants, direct charging systems, subgrade machines, finishing machines, etc., and investigation and adoption in every practical instance should be encouraged, and orders placed early enough to insure their delivery for the present working season.

Producers of materials have organized an association and are making preparations to keep their plants in repair in order to keep up production. Cars will be loaded to their maximum capacity and traced to their destination. Their prompt unloading will be asked for.

Contractor Installs Own Plant for Producing Gravel for Road Job

When a contractor has a good sized road job in a section of the country where commercial gravel plants are few and far between, he may find it profitable to install equipment for producing aggregate right on the job, provided there are adjacent deposits of a grade of material suitable for his work.



Gravel Screening and Washing Plant for 12-Mile Road Job.

The opinion expressed above is that of Mr. G. W. Ledingham of Ledingham & Cooper, general contractors, Bellingham, Wash., who were confronted with just such a situation in carrying out the contract for a 12-mile concrete road near Acme, Wash. The cost of shipping in gravel was practically prohibitive as the location of their job was outside the economic shipping zone of the nearest commercial plant. But they found a fine deposit of gravel in the river bed, close to the road and fortunately this was at a point about midway along the job, making it an ideal site for a gravel plant because it was central with respect to haulage to all parts of the contract.

A complete screening and washing plant with a 500-ft. span, ¾ cu. yd. Sauerman dragline cableway excavator was installed. The excavator was operated in two 8-hour shifts, as an increase in the scale of concrete mixing operations made it necessary to get out double the daily output of gravel contemplated in the original plans. It required about 500 cu. yd. of washed and screened material per day to keep the concrete mixers busy, which meant that about 600 cu. yd. a day had to be excavated and conveyed to the screens by the dragline cableway, the loss in separation averaging about 20 per cent of rejected material. Seven 4-ton motor trucks were used to haul the sand and gravel from the plant to the mixers. The trucks were also operated on two shifts—from 6 a. m. until midnight—and the plant had to be kept at top efficiency so as to come through with full bunkers at the end of the day and not delay the start of the next day's operations.

Alignment, Grade and Width of Modern Highways[*]

By CHARLES M. UPHAM.

Chief Engineer, State Highway Department of Delaware.

Alignment.—In giving consideration of alignment, roads may be divided into two classes: roads located within parks and intended as scenic roads and used mainly by sightseers and tourists, and roads that can be considered as commercial or industrial roads, which would be located within and between business centers, towns, cities, etc.

In the alignment of the park or scenic roads, it is not essential to have long tangents nor direct routes; the only essential requirements of these roads are that they shall furnish lanes of travel for pleasure riders, and shall be properly designed and constructed from the standpoint of safety and beauty. These roads need not be laid off in direct routes, because speed or time is not generally an element to the users of these highways.

The controlling points of the scenic road are entirely different from the industrial road, and consideration should be given beautiful views; preserving of trees; the regard to costly residences, and, in fact, any detail that may serve the purpose of making the road more beautiful. With the controlling points fixed, the only other consideration is that of safety and the expense of construction.

There seems to be a practice along practically all the states that from the standpoint of safety, the alignment of the scenic roads should be such, that the radius of all curves should not be less than 300 ft.; though in many instances it is common practice to use radii of 200 ft. or less.

The commercial road may be described as that road that will most economically serve the commercial or industrial requirements or defined in another way, may be called the direct route.

In considering the alignment of commercial roads, or direct routes, it must always be remembered that a straight line is the shortest distance between two points, and from a commercial standpoint, the shortest way is not only the most direct, but with other things equal, is the most economical; therefore, it seems to be practically conceded that ideally aligned commercial roads are those that are laid in absolutely straight lines.

Where there are costly influences entering the problem that makes it impossible or impracticable to follow the straight line, then the alignment should approach the straight line, and become a compromise of line, grade, and cost of construction.

By the straight line method, it does not mean that two distinct points should be given ultimate consideration, but each and every community and business district lying between these points should be given due regard, and the line should run in the most direct line possible connecting up these intermediate controlling points, provided the line will form a direct route.

More stress has been laid upon the alignment of roads during the past two or three years than ever before. It simply shows that highways are passing through the same stage that the railroads passed through when after exhaustive studies from an economic standpoint, they spent considerable money for the straightening of their lines. The problem of the highway is practically identical with that of the railroad. Much study should be given to final location, for after all, the location of a road is the only permanent detail; therefore, this should approach the ideal as closely as possible.

In the construction of hard surfaced roads, the alignment is well defined, and very little change or slight angle can be plainly seen. If breaks in the line are necessary they should be located on the tops of hills or summits in the grade.

If necessary to use a curve, then the flatter the curve, the safer the road, and this would not jeopardize the beauty or purpose of the road in any way.

When a curve sharper than 24°, or of 1,433 ft. radius, is used, the roadway should be elevated on the outer side and widened on the inner side. This will overcome the tendency of the traffic to skid and make driving both safer and more pleasant.

A very important feature in deciding the alignment of roads, is the consideration to the through traffic. The ideal road is one that will serve through traffic by direct routes and also make it possible that this traffic need not be delayed on account of congested districts. In other words, the best alignment for a through traffic road is a straight line so located as to pass near, but not pass directly through these congested districts. With such a location, the through traffic is not subjected to interference or delay which is always present in the main thoroughfare of towns and villages, nor on the other hand is the town or congested district subjected to the hazard of the through traffic. By such a location the congested districts have all the benefits of a modern highway, but are not subjected to its disadvantages. Therefore, when considering alignment, this is a very important detail to keep in mind.

Under alignment, there may also be mentioned the subject of the width of right of way. This we find in nearly every state has been neglected or it has given considerable trouble, when road developments have been carried on in a modern way. Until recently only in a few states were right of ways obtained wider than 40 ft., or was there any amount of effort made for direct routes or straight lines.

With roadway sufficiently wide to take the amount of traffic and to add to this such space as is generally necessary for shoulders and drainage, a minimum right of way of 60 ft. should be obtained in districts outside of cities and towns, especially if the country is at all rolling.

When the smaller towns are approached or entered, the right of way sufficient width to allow for the widening of the roadway to take the additional traffic should be obtained, as well as sufficient width for the carrying into effect any beautification scheme, such as grass plots, flower gardens, tree planting, etc., that might be developed at any time in the future.

In the case of cities, it is quite advisable in the construction of any road to secure, as soon as possible, sufficient width of right of way to provide for future development, such as might include wide sidewalks, grass plots, areas for tree planting, besides sufficient roadway to take care of the ultimate traffic.

It may possibly be said that through many villages and small cities it would not be practical to secure such width of right of way as recommended, especially after developments in property have been made.

This might be true if it was necessary to bring around this condition immediately, but this could be provided for ultimately by establishing new building lines or property lines, making it compulsory that all future development and rebulding should be a certain distance from the road. In this way, a wider right of way would finally result, with the expense of an immediate change.

Grades.—It may be said that a highway, as a factor in transportation, is no more economic or efficient than its ruling grade.

Grades and alignment seem to be so closely related that many times one is dependent on the other, or one is bettered at the expense of the other. In any case, the ideal conditions should always be kept in mind, and a compromise wherein the maximum of an ideal condition should result.

The same general division can be made with regard to the choice of grade as to line, namely: scenic roads and commercial roads. On the scenic roads, safety and beauty seems to be the controlling factors, while on commercial roads the problem is an economic one, and the requirement is that traffic should use the road at a least cost or effort.

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[*] From a paper presented Dec. 9 at the Louisville Convention of the American Association of State Highway Officials.

In designing the grades for highways there seems to be a general tendency for the states to make an effort to limit the maximum or ruling grade to 6 per cent, with the possible exception of short stretches, which seem to be allowed in most states. This 6 per cent grade was established in the days of horse-drawn vehicles, and while it has served in that purpose, it has not been definitely established at least that this is the most economic grade for motor vehicles. A maximum or ruling grade for motor vehicles is the steepest grade that can be negotiated with minimum of power. This problem is new being studied, but it can only be determined after careful study and experiment and close co-operation with the motor industry.

In most states it is impracticable and almost impossible to hold to a grade as low as 6 per cent and in these cases, if a grade considerably in excess of 6 per cent seems necessary, a study of relocation should be thoroughly made with an end in view of reducing the grade. It is economic to increase the length of line it a reduction of grade will result.

At the beginning and end of all grades vertical curves should be used in order that the grades shall preserve a continuity and can be approached gradually, as well as provide a long line of vision. There is one definite conclusion, however, that we can draw relative to grade; the power to negotiate the grade increases proportionately to the per cent of grade. With this law established, we can see that the level grade would be the ideal grade from an economic standpoint. With this definite law, the problem of grade is somewhat simplified and can be determined. In many cases, more power is absorbed in overcoming the surface resistance than in overcoming the grade.

It was often thought that before a grade or hill was improved it was the grade that was causing the resistance, when, as a matter of fact, the road surface probably caused many times more resistance than the grade. With an unimproved surface the grade resistance is a small percentage of the whole resistance; with an improved road the grade resistance forms a much larger percentage of the whole, showing the necessity and economy of reducing grades, if we wish to retain the advantage when hard surfaces are constructed.

After establishing the level grades, as the ideal economic grade, all efforts should be made to approach this grade in the design and any compromise with line or expense of construction should be made with the ideal grade in mind.

Widths of Pavement.—While the requirements of widths of pavement can be divided into demands for scenic widths and commercial road widths, the demands and requirements are so closely associated that only commercial roads need be considered.

While the width of pavement can be said to almost wholly depend upon the character and amount of traffic, the problem still remains far from being solved on account of its being effected by the variable known as the personal equation; something impossible to solve.

The worst condition that generally exists on a road is when wide trucks are placed side by side. The average width of the wide truck is 8 ft., so it can be seen that two trucks would theoretically just take up the entire space above a 16 ft. road. Practically, however, due to the overhang over the wheels, these trucks might be placed on the pavement so there would be a 2 ft. clearing between the bodies, provided each truck went to the extreme edge of the pavement in passing. This, however, is not often the case, due to the fear of getting too close to the edge of the roadway, and the condition of the shoulder being too uncertain. For this reason it can readily be seen why most states have already relegated to history the 16 ft. roadway and stepped forth to 18 or 20 ft. for a double-track road.

For a two-track roadway, nearly all states are now advocating 18 ft. with a minimum shoulder on each side, 3 ft. in width. A few of the states still adhere to a roadway of 16 ft., but in this case shoulders are always provided whereby the traffic may readily ride on the shoulders, provided it is necessary.

In a three traffic road many states adhere to the 24 ft. in width, but there seems to be a growing tendency that this should be increased to 26 or even 30 ft.

The reports of the American Road Builders Association, covering this subject of widths, recommend that a double-traffic trunk highway should be at least 20 ft. wide with a minimum shoulder of 5 ft. Wherever there is an additional line of traffic 9 ft. should be added to the roadway. Wherever the right of way can be acquired provision shall be made for shoulders of at least 9 ft. in every case. This is for the purpose of future widening of the roadway when necessary.

To widen roadway to certain limits is a step in the ideal direction, but it cannot be said that a roadway should be widened without limit, for after a certain width is reached, and traffic becomes heavy, lanes for traffic should be established, and furthermore, separate lanes for the fast traffic, as well as the heavier or slower traffic should be set up.

The cost of road enters strongly into the determination of width, and when the compromise is made the minimum should be sufficiently wide to take care of the lines of ordinary traffic, plus as much clearance width as the importance of the road and the intensity of the traffic justifies.

Regardless of width of roadway, the shoulders should be maintained in a serviceable condition for cases of emergency. If the roadway is not sufficiently wide to provide for traffic, the shoulder will receive considerable of this traffic and cause excessive maintenance. Many times this excessive maintenance would pay the cost of construction of wider roadway, which would result in a much lower shoulder maintenance and provide a more satisfactory pavement.

In level countries where alignment is straight and the curve flat there seems to be no necessity for an increase in width from the general widths required for the various number of lines of traffic, but in countries where the alignment is not straight, it is quite essential that the width on all curves of 10° and over should be materially increased.

The width of increase on pavement should take place on the inside of the curve and begin at a point outside of the point of curvature and extend beyond the point of tangency. The additional width varies according to the degree of curve and local conditions.

Many states have, after deciding upon their unit of width, made their width of road entirely dependent upon the amount of traffic. Where the traffic is up to 3,000 or 4,000 vehicles a day, the roadway is not less than 18 ft. in width; where the traffic averages about 5,000 vehicles and over during the day, the roadway is made at least 26 ft. and sometimes 28 or 30 ft. In this instance satisfactory shoulders should be provided, so if by chance or accident the traffic is forced off the metal roadway on to the shoulders.

Some states have decided that if a hard surfaced pavement is to be used, the minimum roadway, in order to provide for a single line of traffic, should be at least 9 ft. in width and preferably 10 ft. A pavement of this kind should not be attempted unless there are satisfactory shoulders of sufficient width and character whereby vehicles can pass without danger, or that turnouts should be provided at intervals.

Culvert Form Built of Interchangeable Units

A culvert form built of interchangeable units is being used quite extensively in highway work. A single unit consists of two sides held apart by spreader rods and one arched member with spreader bars which are so arranged as to form a collapsing feature. The arched members have a radius of approximately 12 in. and are used separately in building the smaller sized culverts. These members are set parallel to each other for building culverts wider than 24 in., and in this position plates are used to cover the intervening space between the apexes. These plates are 2 by 3 ft., and are reinforced on the under side by a special angle bar arrangement, which supports itself in either position. The plates are used lengthwise with the arched members to produce a 48-in. span, and crosswise to produce a 60-in. span. For a 24-in. span the arched member is placed on the sides so that it passes down between the sides and rests on the cross rods.

Each unit is then complete, 6 ft. long, about 27 in. high and 24 in. wide. The slots in the heads receive the ears on the sides and top in several different positions. For a 24-in. culvert the ear in the top passes through the center horizontal slot in the head, and the ear on each side passes through the vertical slots in the head, and pins are used to hold them in place. The wings are placed at the ends of the head. The parapet form is bolted to the head. The form units may be paired and used side by side, the same as the arched members, to build culverts either 48, 60, 72, 84, 96 in. or wider, according to the number of units used. Slots are cut in the heads for most of the standard sizes, and plates are used to connect the units. The form described above is known as the Whalen Standardized Culvertform. It is manufactured by the Concrete Form Co., Inc., Syracuse, N. Y.

Pouring Concrete in Whalen Culvert Form.

Personals

Arthur Parker has been appointed city engineer of Cheyenne, Wyo.

Eli Abbott has been appointed highway engineer of Leflore county, Mississippi.

N. R. Dinsmore has been appointed superintendent of street repairs of Akron, O.

G. L. Baxter has been appointed testing engineer of the state purchasing department of California.

W. H. Johnston, Reno, Nev., has been appointed a member of the Nevada State Highway Commission.

George A. Seymour, Royal Oak, Md., has been appointed county road engineer of Talbot county, Maryland.

Louis Beauman has been elected engineer in charge of the highway maintenance department of San Joaquin county, California.

W. E. Howe, assistant city engineer of Topeka, Kan., has been appointed county engineer of Neosho County, Kansas, with office at Erie, Kan.

Cecil L. Road, county engineer Lucas county, has been elected president of the Ohio Engineering Society. Jno. Laylin, Norwalk, O., was elected secretary-treasurer.

George E. Datesman, formerly director of public works of Philadelphia, has opened offices in the Franklin Bank Bldg., Philadelphia, as a consulting engineer on municipal operations.

Robert B. Patterson, field engineer of the Utah state road commission, has tendered his resignation to be effective Jan. 31. He has accepted the position of road engineer of Utah county.

Frank Quinn, executive secretary of the Warren, Pa., Chamber of Commerce, has been appointed to the combined offices of city manager and Chamber of Commerce secretary of Petoskey, Mich.

Frank Mitchell has resigned as county engineer of Thomas county, Georgia, to accept appointment by the State Highway Commission as engineer in charge of paving work in the Second District.

M. O. Bellingrod of this city, at present assistant engineer of the Georgia & Florida Railway Co., in Augusta, has been appointed assistant division engineer in the Georgia state highway department.

Robert T. Jacobsen, acting city engineer of Fargo, N. Dak., since June, 1919, has been appointed city engineer. He succeeds Frank L. Anders, city engineer for the past 10 years, who resigns to specialize in private practice.

John J. Griffith, of Indianapolis, county surveyor of Marion county, has been elected president of the Indiana County Surveyors' Association. Frank L. Catt, of Rush county, was elected vice-president; Charles Boone, of Hancock county, secretary, and A. H. Fry, of Wells county, treasurer.

J. J. Collins, W. D. Hammond and Linton Hart, formerly of the Raymond Concrete Pile Co. and the Dock Contractor Co., have organized the Rollin Construction Corporation and will engage in general construction with offices at 90 West street, New York City, and 80 Boylston street, Boston, Mass.

E. W. Canning, formerly a superintendent of construction with the J. H. Grozier Co. of Hartford, and the Stone & Webster Co., and John B. Leary, formerly on the engineering staff of Ford, Buck & Sheldon, Inc., have formed a partnership under the firm name of Canning & Leary, and will do a general building contracting business, with headquarters in the Plant building, Bristol, Conn.

Rudolph P. Miller has been appointed superintendent of buildings for the Borough of Manhattan, New York City. Mr. Miller began his services in the city government in 1895 as a building inspector. In 1914 and 1915 he was retained by the Board of Aldermen to revise the building code, the present code being the result of that work. In 1916 he was appointed the first chairman of the newly created Board of Standards and Appeals.

Walter B. Hogan has been appointed city engineer of Stockton, Calif.

James R. Nevin has been elected county engineer of Jefferson County, Iowa, succeeding Don L. Teal, who has accepted a position as construction engineer with the state highway commission with headquarters in Ottumwa, Ia.

Prof. G. V. S. Skelton, head of the civil engineering department at Oregon agricultural college, has been elected president of the Northwest Society of Highway Engineers. He succeeds R. M. Gillis, Kalama, Wash. Other officers elected were: First vice-president, R. H. Monson, Seattle; second vice-president, R. A. Klein, who is secretary of the Oregon State Highway Commission; secretary, C. B. McCullough, head of the bridge department of the Oregon state highway; treasurer, G. C. Reiter, resident engineer at Hillsboro.

Frank C. Snow, assistant professor of civil engineering, Montana State College, has been appointed professor of highway engineering at Georgia School of Technology, Atlanta, Ga. He also will serve as director of the highway materials laboratory at the Georgia Technology and as consulting highway engineer for Fulton County, Georgia. Mr. Snow is a graduate of Ohio State University, receiving the C. E. degree in 1906. He has been city engineer of Findlay, O., engineer with the Bozeman, Mont., testing laboratory, and consulting sanitary engineer for the State Board of Health of Montana.

George E. Martin has resigned as associate professor of highway engineering, Purdue University, to become consulting highway engineer for the Barrett Co., with headquarters in Chicago. Prof. Martin graduated from the School of Civil Engineering, Purdue University, in 1909. In 1914 he returned to Purdue to take charge of the newly organized work in highway engineering. In October, 1917, he left the university to enter the U. S. Engineer Corps. He served as a captain in the 23rd Engineers until July 2, 1919. About 15 months of that time was spent in France. He returned to the university in September, 1919.

Industrial Notes

The G. H. Williams Co., Erie, Pa., has established an eastern office at Room 317, 30 Church street, New York City, in charge of H. F. Randall.

Mace Moulton, Jr., who has been for the past 6 years New England sales manager for the United States Asphalt Refining Co. of New York and Baltimore, has formed the firm of Mace Moulton, Jr., Inc., with offices at 6 Beacon street, Boston, to handle the sale of bituminous road materials and pavements.

A. W. Ransome, formerly manager of the New England territory for the Blaw-Knox Co., with offices at Boston, Mass., has been transferred to San Francisco in the capacity of manager of the Pacific Coast territory with offices in the Monadnock Bldg., San Francisco. O. A. Olstad, formerly connected with the New York office, has been made manager of the New England territory, with offices in the Little Bldg., Boston, Mass., succeeding Mr. Ransome.

The Ransome Concrete Machinery Co., of Dunnellen, N. J., has placed its New York office, 150 Nassau street, in charge of Lemuel Smith, Jr., F. G. MacDonald and James H. Fitzgerald. Mr. Smith, who has been with the company for a number of years, has for the past two years been assistant sales manager. Mr. MacDonald has been selling Ransome mixers in the New York territory for a number of years, and Mr. Fitzgerald has been in charge of the pneumatic mixer department of the Ransome Co. for a number of years.

The Westinghouse Electric & Manufacturing Co. has announced a number of promotions among its officials at East Pittsburgh. Among the more important of these are the following: Alexander Taylor, for many years manager of works, has been made assistant to vice president in general charge of all plants of production, stocks and stores. R. L. Wilson has been promoted from position of general superintendent to works manager of the East Pittsburgh Works. E. R. Norris has been appointed director of works equipment, in charge of machinery, tools and methods in the various plants. C. B. Auel is made manager of the employes service department. Other appointments announced were: G. M. Eaton has been made chief mechanical engineer of the company; C. W. Johnson and H. W. Cope, assistant directors of engineering; C. H. Champlain and E. S. McClelland, assistant works managers; John E. Bonham, assistant to works manager; E. S. Brandt, supervisor of equipment and methods. The following were appointed as managers of the engineering departments indicated: A. M. Dudley, automobile equipment; R. P. Jackson, material and process; F. E. Wynne, railway equipment department; and G. H. Garcelon, small motor.

Trade Publications

The following trade publications of interest to engineers and contractors have been issued recently:

4-Wheel Scraper.—Baker Manufacturing Co., Springfield, Ill. 48 page catalog devoted to dirt moving with the Baker-Maney 4-wheel scraper. Description of the machine and methods of operation are given, as well as numerous construction views. Cost data on moving dirt also are given.

Motor Truck Axles.—Clark Equipment Co., Buchanan, Mich. A 50 page brochure, printed on heavy coated paper and illustrated with pen etchings, describing the plant, personnel and processes for manufacturing the Clark line of internal gear drive axles for motor trucks. It contains an interesting chapter on axle development.

Road Graders.—J. D. Adams & Co., Indianapolis, Ind. 64 page catalog of the Adams adjustable leaning wheel graders. Full descriptions of each machine are given as well as complete specifications. Illustrations of Adams graders at work in various parts of the country are given and the principle of the leaning wheel feature of these graders is illustrated and explained. In addition to graders, the catalog covers the Adams line of road maintenance and construction machines and tools.

Bearing the title, "The Home Front," the Traylor Engineering & Manufacturing Co., Allentown, Pa., has published a 144 page book giving a record of its activities during the past 5 years. This company was one of the first in the country to engage in the manufacture of war munitions, its first contract being secured on May 10, 1915. Interesting descriptions of the plant, equipment and methods used in this work are given. Descriptions also are given of the other war activities of the company, such as the building of ships and the manufacture of marine engines. The account of the construction of Ferris design wooden cargo ships is particularly interesting.

Waterworks and Hydraulics Monthly Issue

ENGINEERING AND CONTRACTING

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The four rotated special monthly issues and 4 quarterly issues of E. & C. (52 in all) entirely cover the civil engineering and contracting field at $3.00 a year. The special quarterly issues relate entirely to foreign engineering and construction practice. The *articles* in the first two issues of each month completely cover the municipal engineering and contracting field. The *articles* in the first and fourth issues of each month completely cover county engineering and highway engineering and contracting. The *articles* in the 3rd and 4th issues of each month completely cover steam and electric railway location, design and construction. See the "masthead" on the first page of the Weekly News Section for information about our weekly contract news.

Roads and Streets—1st Wednesday
- (a) Roads
- (b) Streets
- (c) Street Cleaning
- (d) Municipal Miscellanies
- (e) Management and Office System

Waterworks and Hydraulics—2nd Wednesday
- (a) Waterworks
- (b) Sewers and Sanitation
- (c) Irrigation and Drainage
- (d) Power and Pumping
- (e) Management and Office System

Railways and Excavation—3rd Wednesday
- (a) Excavation and Dredging
- (b) Rivers and Canals
- (c) Quarries and Pits
- (d) Railways, Steam and Electric
- (e) Management and Office System

Buildings and Structures—4th Wednesday
- (a) Buildings
- (b) Bridges
- (c) Harbor Structures
- (d) Miscellaneous Structures
- (e) Properties of Materials
- (f) Management and Office System

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Are Prices About to Fall?

A great reduction in exports from this country is imminent because foreign countries have practically exhausted their credit and have only sufficient gold for their domestic needs. During 1919 our balance of trade (excess of exports over imports) was about 4.5 billion dollars. Since all the nations of the world combined have only 9 billions of gold, of which this nation already has one-third, it has been evident for some time that our export trade must ultimately receive a check. The check has apparently come.

What will be the effect upon American prices if our exports to Europe take a great and sudden drop? Obviously the effect will be the greatest in the industries that have been furnishing most of the exports; but there will also be some effect upon the general price level. Prior to the war the total income of all Americans was estimated to be about 50 billion dollars. Due to rises in wages and profits, the present income is probably about 75 billion dollars. If, therefore, our exports in 1920 should decrease 4.5 billion dollars, the decrease would be only 6 per cent of the total income.

In a falling market there is a tendency for price levels to decrease much more rapidly than the actual curtailment in business would alone warrant, and the converse is true in a rising market. Therefore, a rapid decrease of, say, 6 per cent in total annual income is apt to cause about 12 per cent decrease in the general price level. While this would be a large decrease in prices, it must be remembered that index or average prices now are more than 100 per cent in excess of pre-war prices.

28 Pages=40 pages

The 28 pages of articles in Engineering and Contracting contain as many words as 40 pages of the size and typography commonly used by other engineering periodicals. Ours is the same size of type and type-page as that of The Literary Digest—easily read, yet giving a large volume of reading matter per page. Our 28 pages of articles would fill 112 pages of the standard 6x9 in. text-book. It would take 10 such books of 580 pages each to hold all the articles printed each year in Engineering and Contracting, to say nothing of our weekly construction news.

When our civil war ended in 1865 average prices had risen 105 per cent during the four years of war, a rise almost the same as during the recent world war. During our civil war the amount of money had increased 50 per cent, or almost exactly the same increase as occurred in this country during the recent world war. But it was not till 1878, or 13 years after the end of our civil war, that average prices got back to the level of 1861. In short, prices dropped only 8 per cent annually for 13 years, although they had risen 26 per cent annually during the four years of war.

The three great factors that caused the drop in prices following our civil war were: (1) The psychological effect of a shrinking market, (2) the increase in population, and (3) the increase in labor efficiency.

We have already spoken of the psychological effect, and need only repeat that business men naturally tend to curtail their production when price levels are falling.

Population increased about 3.5 per cent annually after the civil war, due mainly to immigration. Since each added worker requires a certain amount of money directly for his personal needs as well as indirectly for financing his industrial operations, it follows that an increase in population tends to reduce price levels by decreasing the per capita supply of money. This was partially offset (1865-1878) by an increase in the total supply of money.

The third factor operating to reduce prices after our civil war was the increase in efficiency of the average producer. This was due in part to the rapid expansion of our railway system, which opened up rich agricultural lands. Perhaps the main factor was the rapid increase in the use of labor saving machinery of all kinds. That was an era of enormous improvement in farm implements, which was reflected by the relatively slow increase in agricultural population compared with the very rapid increase in urban population. Also our manufacturing efficiency increased at a rapid rate, mainly because of the invention of numerous labor saving devices.

Contrasting the relative intensity of the factors that affect prices today with those following the end of our civil war, we find nothing that leads to an expectation of a more rapid decline in prices than the 8 per cent annual decline during the 13 years following the civil war. It is true that the psychological factor is about the same in both cases, and will tend to lead business men now, as it did in 1865, to curtailment of production on a falling market. But, on the other hand, there is likelihood that our per capita money supply will increase more rapidly than during 1865 to 1878, both because our population is never again apt to increase at the rate of 3.5 per cent annually, and because foreign nations owe America and Americans 18 billion dollars. From 1900 to 1910 our population increased 20 per cent, about half of which was by immigration.

What of the probable rate of increase, in average productive efficiency per worker per annum? The outlook is by no means hopeful for the near future. Labor unions during the year 1919 were granted an average reduction of 8 per cent in daily working hours, and the end is not in sight. If workers were to respond to reduced hours by corresponding increases in hourly output, this economic element could be ignored, but the fact is that they usually adhere to their original hourly speed. It is perfectly idle for the editors of the daily press to call upon workers to increase their output, as any man experienced in handling men knows. A few labor union leaders are beginning to suggest increased outputs as a means of decreasing prices and increasing wages, but we fear that it will be many years before this advice will become a slogan of the working classes.

As an effective factor in causing a steady decrease in prices, there is left what? The efforts of brain workers—educators, pure scientists, inventors, engineers and business men. We put educators at the head of the list. In this class we include all writers whose object it is to spread knowledge that will increase human efficiency—notably the authors of technical articles and books. Were our schools and colleges better planned and better manned, our teachers would be far more effective than they are likely to be during the next ten years as trainers of efficient producers. But even as it is, they are the greatest factor in American progress, and are likely to become relatively greater; for here and there a teacher inspires some boy to become a great brain worker. And all economic progress is attributable, in the final analysis, to brain workers.

Summing up, there seems to be little likelihood of a general drop in prices at a rate faster than the 8 per cent per annum that occurred between 1865 and 1878. It is noteworthy that the price index is higher today, 15 months after the end of the war, than it was when fighting ceased; whereas prices receded about 10 per cent during the year following the end of our civil war, as may be seen from the price curves given in Prof. Irving Fisher's little book, "Why Is the Dollar Shrinking?" (1914, Macmillan Co., New York, 1.25).

Typhoid Fever in Massachusetts. The typhoid mortality of Massachusetts has fallen from 12.2 per 100,000 in 1910 to 4 per 100,000 in 1918, according to a paper by George T. O'Donnell, presented at the last annual convention of the American Public Health Association. Since 1896 no considerable number of cases of typhoid fever have been caused by the public water supplies of the state. Over 90 per cent of the population now has a public water supply.

The Growing Practice of Training Engineering Students to Read Current Periodicals

As a rule, methods of teaching engineering, in spite of the criticism to which they are constantly subjected, seem to change no more rapidly than the methods used by practicing engineers. To this rule there appears to be at least one exception. We refer to the rapidly growing practice of teaching students to read current engineering periodicals. Prof. H. P. Boardman, of the University of Nevada, recently said:

> The writer has for a number of years given a course in current engineering literature. This has consisted of assigned readings and discussions from current engineering periodicals and technical society proceedings. The student is required to prepare his assignment, so he can give the gist of it orally, with the aid of brief notes if he wishes, explaining the illustrations, if any, and discussing any controversial points.
>
> The assignments are so made that each student will occupy from one-half to a full hour period when his turn comes. It is a one-credit course per semester and if there are more than four or five students in the class they meet for two periods per week, so that each one will come on the program about once in every two weeks.
>
> This was for some years made a requirement for senior civil engineering students, the idea being that they would get more out of the course than less advanced students, but recently it was made an underclass course, elective for freshmen and sophomores, and it worked well during this second semester of 1918 and 1919 with a class of seven, including members from all of the engineering courses
>
> Many of the assignments are non-technical, such as discussions on engineering education, professional ethics, salaries for engineering work, the future of engineering, etc. The asking of questions and expression of personal views or statement of personal experience is encouraged. Since the instructor can not read all articles before assigning them, some points will be beyond the understanding of the students. This is well, for it often serves to show them their need of further education and experience.
>
> The whole tendency of the course is to put the students in touch with real engineering life and develop a desire to keep up to date as well as to increase their interest in their technical studies. Incidentally, the effect on the instructor of the course is good also.

Prof. Boardman mentions several of the advantages derived from such a course of technical reading, but does not name what is, in our opinion, the strongest reason for requiring students to read engineering periodicals. Between the years of 16 and 25, most young men form nearly all their lasting habits. At least we have for this statement the authority of America's greatest psychologist, the late Prof. William James. If so, how supremely important does it become to habituate engineering students to search for information.

Of course there is a certain amount of "searching for information" involved in the mere reading of an assigned textbook; but it should be evident that what is "assigned" to a student to read differs in its effect upon his mind from what he himself discovers in print. It is a revelation to the average student to find that on a given subject the files of the technical periodicals often contain a hundred times as much valuable information as in a book on the same subject. Many an engineering student graduates without having discovered that fact for himself; and, judged by their meager libraries, a very large percentage of graduate engineers fail ever to learn that their textbooks contain only a very small percentage of the collective knowledge that their titles cover.

Textbooks dwell mainly on basic principles, and it is proper that they should, since minor principles and details can not all be taught in school. But, somehow, the average engineering student comes to regard the principles that he has learned as being adequate for all ordinary purposes, if intelligently applied. Not a few teachers encourage this erroneous belief. Something, therefore, should be done to make young men realize that the best of textbooks is woefully inadequate as an aid in solving all the economic problems that may be classed under its name. Take, for example, hydraulics. Buy all the text books on the subject, study them thoroughly. Then tell, if you can, what type of engine should be used to raise water 100 ft. from a well to irrigate 160 acres of arid land. You may be well informed on all the principles given in your textbooks, yet, give an erroneous answer to this question. The correct answers to such questions are usually in print somewhere, but the textbook "fan" doesn't know it, because his habits do not lead him to search beyond the covers of his "five foot bookshelf."

Dr. Eliot is credited with having said that a liberal education could be secured by mastering the contents of a list of books that would barely fill five feet of shelf room. Like most generalizations of this sort there is only a modicum of truth in it. Education is not a mere matter of understanding and of memorizing. It consists mainly in forming good habits, habits of thoroughness in searching for facts, habits of careful analysis of the data, habits of classification of knowledge, habits of comparing and measuring the facts, habits of reasoning by analogy, habits of systematically deducing conclusions, and so on through all the psychological processes that a well trained, scientific mind exhibits.

Will Living Expenses Decrease?

The National Industrial Conference Board has made extensive inquiries as to the cost of living, from which it has reached the following tabular conclusions as to the increase of cost to the average city family, comparing Nov., 1919, with July, 1914:

	Per cent of total.	Per cent increase.
Shelter	18	38
Fuel and light	6	48
Sundries	20	75
Food	43	92
Clothing	13	135
Average	..	82

The column giving "per cent of total" is based upon prewar data gathered by the U. S. Bureau of Labor Statistics.

During the four months from July to November, 1919, the average living expense rose nearly 6 per cent, the principle increments being in clothing (18 per cent) and rent (8 per cent).

It seems probable that there will be a sharp drop in clothing prices, because Europe is curtailing its imports and is increasing its exports of textiles. Just prior to the great war, textile imports to America were increasing rapidly under the low tariff rates. Those rates have not been raised. Europe will struggle to pay its debts to America, and is perhaps better able to pay in textiles than in almost any other class of necessities. Hence, in spite of the great rise in European wage rates, we may look for a steady increase in textile shipments to America.

The American index price is now about 105 per cent above the prewar price, but clothing is 135 per cent above the prewar level. Clothing is excessively high and is likely to fall. On the other hand, rent, fuel and light are still far below what may be expected.

Viewed as a whole, therefore, there is little prospect of a marked decrease in living expenses during the next year or two. Unless living expenses do decrease considerably, labor troubles are likely to be quite as serious during the coming year as they were in 1919.

Is a New Organization Necessary to Further Non-Technical Interest of Engineers?

To the Editor: A debatable question no longer exists as to whether engineers of the country should get together in furtherance of their non-technical interests. The attitude everywhere is not whether, but how shall this end be achieved? Some engineers evidently think that a sort of super-organization of the founder societies should be brought into existence, or perhaps a federation of all societies, but an increasing number are coming to the conclusion that the end will be best accomplished by using the well tried machinery at hand, designed for this purpose, namely that of the American Association of Engineers.

A striking omission occurs in the report of the joint conference committee of the older societies, one which by its absence attracts comment throughout the rank and file of the profession, namely the neglect to refer to the fact that the work proposed to be done has already been undertaken and is well advanced by the American Association of Engineers, with a membership now larger than that of any other national society. From all parts of the United States is coming the question "Why has the joint conference committee's report been silent on this vital question?"

In answer to this question and in the firm belief that the rank and file of the profession are waiting for such an announcement, the secretary of the American Association of Engineers on December 20, 1919, addressed the following letter to the governing bodies of the founder societies:

"The development of the opinion in the founder societies in favor of giving attention to the non-technical side of the engineer's life has led several members of each to ask the American Association of Engineers to write simultaneously to the governing bodies of these societies offering its service in problems of public and professional welfare and asking their co-operation.

"We have read the report of the joint conference committee and believe that the American Association of Engineers, a successful going organization, is capable of carrying forward the non-technical activities recommended in the report fully as well and perhaps better than the organization recommended by the conference report.

"The activities of A. A. E. are confined to social and economic problems such as legislation, employment, compensation, political and civic endeavor. A. A. E. takes in everyone of good character in the engineering profession and seeks to mobilize all engineers for joint action. It gets its support from the man back home without any intermediate representation so that it is able to do the things that lie close home and that make living as an engineer worth while.

"If the founder societies elect to co-operate with A. A. E. in the work it is doing and in similar non-technical activities, it would be our understanding that such support would not be financial and would in no way interfere with present prerogatives and privileges of the founder societies.

"This letter has been approved by our executive committee at its meeting December 20, 1919. We are enclosing copy of our constitution for convenient reference."

Let us have full discussion. The great body of engineers who have given the matter thought evidently believe that the ends to be attained from the human side must be reached by a strong, well built and thoroughly democratic organization, devoted exclusively to these ends and organized for effective action in ways which the men of experience in human and political activities have found to be most effective. On the other hand, they feel that the purely scientific societies, organized for the investigation of natural phenomena and their application, which elect for their officers men distinguished by research and technical achievement, cannot by mere federation and delegation of power through complicated machinery achieve important results for the welfare of engineers as men and citizens.

Are you in favor of unity along the lines of the above letter? If so, write the editor of this paper, sending copies to the secretary of the national technical society of which you are a member, and to the secretary of the American Association of Engineers.

C. E. DRAYER,
Secretary, American Association of Engineers.

Chicago.

Cost of Water Treatment at Omaha, Neb.—Water treatment at Omaha consists of coagulation, sedimentation and chlorination. The average amount of chemicals used in 1918 was as follows:

Lime, per gal. treated	0.82 grains
Sulphate of alumina, per gal. treated	2.05 grains
Chlorine gas, per 1,000,000 gal.	2.59 lb.

The cost of water treatment for 1918, according to the Public Service Bulletin of the Metropolitan Water District, was as follows:

	Per 1,000,000 gal.
Chemicals	$3.03
Applying chemicals, supervision and labor	0.707
Operation and maintenance of basins	0.349
Wash and waste water	0.333
Depreciation of basins and laboratory	0.841
Interest on investment at 4½ per cent	5.182
Total cost of treatment	$10.445

Method of Constructing 1,800 Ft. Long, 30 In. Flexible Joint Submarine Pipe Line

To allow for the expansion of the Federal Shipbuilding Co. and also for the delivery of an adequate water supply for the city of Bayonne, N. J., two 30-in. land lines 3,300 ft. long and two 30-in. flexible joint submarine pipe 1,800 ft. long were recently completed.

The submarine work was particularly interesting and was described in a paper by Frances H. Sherrerd presented at the December meeting of the New York Section, American Water Works Association. The following notes from this paper describe construction methods

Class D pipe with a modified Ward joint was used. The spigot end of the pipe is ball-shaped, machined to a true surface and limited to within 1/32-in. of the prescribed diameter with a slight raise to the barrel of the pipe at the inner end to act as a bumper in case of an accidental deflecting of the pipe to a greater angle than the 10° allowed in the specifications. The bell end is a socket with a ring machined to the same shape as the ball 6 in. in from the face of the bell and about ¾-in. wide, straight on the inner side and sloping on the outer. Two grooves were cast in for the lead. A steel tire was shrunk on the bell end to give greater strength.

The average amount of lead used was 155 lb., and the depth of joint about 5½ in. as one strand of yarn was used.

Great care was used in handling the pipe to prevent scarring of the balls. The machined surfaces were scraped, cleaned and oiled before laying. Any sandholes or defects which passed the inspection at the foundry were repaired by boring small holes—larger at the bottom than top—and filling with Babbit metal.

The floating equipment consisted of two large derrick scows carrying an air compressor and pumps, one deck scow, one large launch and a large cradle from which the pipe was laid. The cradle was built of timber firmly braced and bolted with a curved track to carry the pipe. The track rested on eight 12-ft. members, chords of an arc of a circle of 86 ft. radius each segment being 8°. The long chord at the top of the cradle was about 91 ft. The width of the cradle over all was 16 ft. and the tracks about 2 ft. 6 in. The cradle was swung between one derrick scow and the deck scow in such a manner as to allow of easy raising and lowering to prevent too great deflection of the pipe at the bottom of the cradle caused by the motion of the tide and also to remain within the limit of deflection on the slopes on each side of the river.

The plans required the laying of the two lines on 20 ft. centers and a trench 40 ft. wide on the bottom was dredged at a depth of 32 ft. below mean low water between pierhead lines. All mud was removed and replaced with sand clay and the uneven bottom smoothed out within reasonable limits. About 100,000 cu. yd. of material was dredged.

One derrick scow was used to load pipe at the dock and to assist in the handling of the cradle. The two other scows firmly lashed and carrying the cradle were anchored in such a way as to carry the center of the cradle in line with rangers set on the shore.

One length of pipe on the start was made fast in an anchorage of piles on the short—then two sets of two lengths each were made up on the deck of a scow and lowered in line—then the joints poured and caulked and laid on the lower end of the cradle, the upper end having been hoisted high in the air. After that each length was laid separately in the cradle and lashed securely so that the whole might not slide. The bell end of the last length laid was blocked off of the curved track so that the spigot end of the one to be laid could be lowered leaving the two in nearly a straight line. Care was taken to see that the last joint made was not deflected too much. The joint was then made and caulked hard, the block taken out and joint broken by lowering into the curved track again. The lashing on the pipe was then loosened and scows and cradle moved back in line by tightening and loosening anchor lines.

Each day's work was inspected from the inside and any dripping joints or bad bends were noted.

The first line was laid at the rate of 6.8 lengths per day and the second at 7.9. The best day's work was 18 lengths and a rate of 12 lengths per day could easily have been maintained after organization had it not been for delay in dredging and bad weather. The force required for laying consisted of three coulkers, three riggers, three engineers, four laborers.

The specifications required both an air and water test. Nearly all leaks showed at 10 lb. air pressure. The pressure was finally raised to 70 lb. but all leaks that showed at 70 also showed at 40.

On the first line after repairing all visible leaks the pressure was raised to 72 lb. at 4 p. m. At 8 the next morning it was 61 lb. and on the second line at 3 p. m. the pressure was raised to 70 lb., and at 8 the next morning was 55 lb. in spite of an air leak in one of the valves. The water leakage allowed amounted to about 1 cu. ft. a minute for 24 hours. The lines were filled with fresh water. The leakage was so small that the pumps could not be run slowly enough not to exceed the required pressure.

In the first line the pressure was raised to 108 at 3:30 p. m. At 5:30 it was still 108 and at 8 the next morning was 91½ lb. It took 50 ft. of water pumped in 11 minutes to bring it back to 108 lb.

On the second line the pressure was raised to 100 lb. and after one hour fell to 98 lb. It took 7 ft. of water pumped in 6 minutes to bring it back to 100. After 20 minutes there was no perceptible loss in pressure.

The pipe was covered with a sand blanket 3 ft. deep by means of a derrick scow equipped with a hopper and pipe which could be adjusted with a telescope arrangement to fill almost exactly to the required depth. This and the construction of two large concrete blocks over the anchor piles on the shore end completes the job.

Relocating Poorly Set Meters Increases Efficiency of Reading Staff

By relocating water meters so they could be readily reached by the reader the efficiency of the meter reading staff of the Water Department of Newark, N. J., has been increased about 50 per cent. The Newark experiences are described by Mr. Morris R. Sherrard in the January Journal of the American Waterworks Association.

This work was done by first obtaining from the readers as they made their regular rounds a list of the inaccessible meters. Then inspectors visited them and studied the best remedy for each of these cases. The owner was then notified to make the change and the reason for it was explained. As tthe purpose of the water department was to secure the maximum improvement as quickly as possible, cases of serious opposition to making the relocation were given little attention until the first campaign was well along toward what it was foreseen would be a satisfactory conclusion. The strong objectors then received attention, and the changes were brought about by using such measures as seemed best fitted to the conditions of each case. The practical outcome of the work has been an increase of about 50 per cent in the efficiency of the meter reading staff, a result of decided importance in a city of nearly 500,000 inhabitants. The result also shows conclusively the importance of locating meters originally in the most accessible place available, something which it is thought will be of interest to water departments generally.

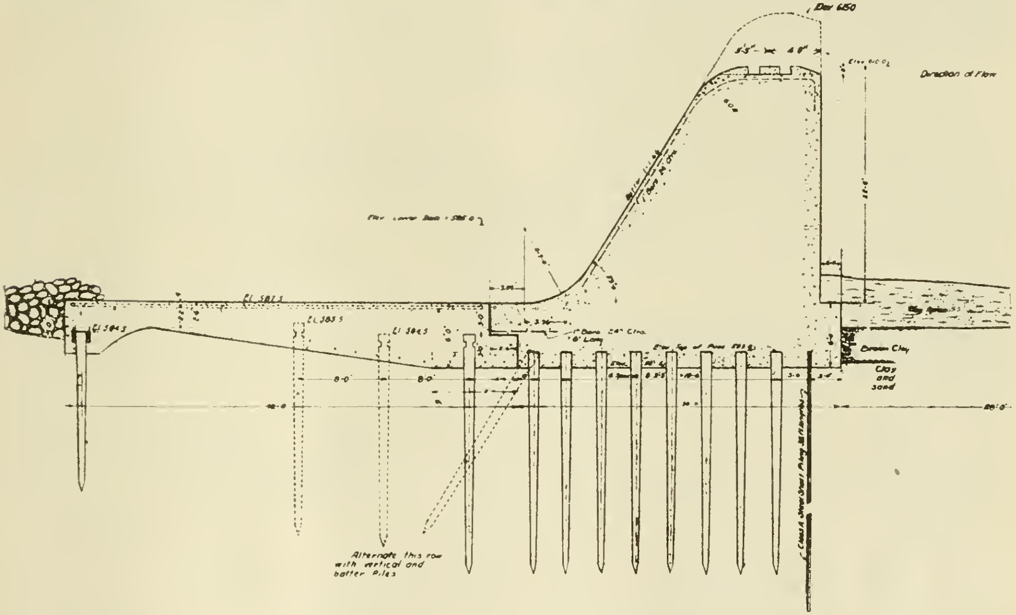
Army Water Supply Service.—The Illinois Section of the American Waterworks Association at its fall meeting on Dec. 10, adopted a resolution stating that the permanent organization of the army should include a water supply service whose personnel should consist of officers and men of especial skill and experience in the design, construction and operation of waterworks, and of sanitary engineers, bacteriologists and chemists, who have made a specialty of taking care of the quality of water supplies. It also was the opinion of the convention that, in addition to a permanent skeleton organization, the water supply service should include a reserve corps from which there can be mobilized in the shortest possible time, men of such experience and attainments as would qualify them to be given responsible charge of providing adequate and safe water supplies for our troops, wherever stationed, from the training camps to the first line trenches.

New Storage Dams in Illinois

Two more cities in Illinois are undertaking the construction of dams to provide storage for their municipal water supply. The city of Jacksonville has just completed an earth dam and is beginning to derive the benefits in the way of increased property values and freedom from water shortage, while Decatur is about to take bids for an earth and concrete dam on sand foundation. The dam at Decatur will form the largest impounding reservoir in the state.

A description of construction methods for the Jacksonville dam and the essential features of design in the Decatur dam are contained in a paper by Samuel A. Greeley, Consulting Engineer, Chicago, and R. S. Rankin of the same office, read Jan. 21 at the 35th annual convention of the Illinois Society of Engineers. The following notes are from the paper:

Earth Dam at Jacksonville.—Jacksonville, one of the oldest cities in the state, has been contending with the water supply problem during nearly its entire existence. Originally, a small impounding reservoir supplied the town, supplemented shortly after by another small reservoir formed by a low dam across the South Fork of the Mauvaiseterre Creek. These two sources later proved insufficient and other means were sought from time to time. Wells in the Illinois bottom lands did not prove a success and finally some drift wells were sunk north of the town. The water from these wells with the other sources form the present supply. The quantity is inadequate and the quality unsatisfactory.



Spillway Section of New Dam for Water Impounding Project of Decatur, Ill.

The present population is about 16,000 and, in addition, there are several public institutions which bring the total population up to about 19,000. The city is fully metered and has an average daily consumption of about 1.25 million gallons per day. The maximum demands are modified by a storage reservoir holding a day's supply and located high enough to provide a gravity supply.

Upon investigation, several possible sources of supply were apparent: impounding reservoirs on any one of four streams in the vicinity, and enlarging the present well system. All factors considered, it was finally recommended that a new impounding reservoir be formed by constructing a new dam across the South Fork of the Mauvaiseterre Creek adjacent to the old pumping station. The total tributary area is about 27 square miles, 2½ square miles of which supplies a small reservoir incorporated in a park.

The new reservoir will have a maximum depth of 14 ft. to the spillway, flood approximately 240 acres with water at the crest elevation, and contain about 430 million gallons. The available draft will average 1.5 million gallons per day and 2.0 million gallons per day in all but the very driest years.

Should future demands require more water, additional storage may be obtained upstream or an impounded supply from an adjacent watershed may be developed and pumped over a low divide.

The city voted a bond issue to finance the project in accordance with the recommendations. The length along the crest of the earth section is about 600 ft. and the height is 22 ft. The spillway is 160 ft. long and is set 8 ft. below the top of the earth embankment. Provision is made for a flood flow of 4,500 sec. ft. with a 4 ft. flow over the spillway which is equivalent to 167 sec. ft. per square mile. The spillway is practically a submerged weir with discharge into a sloping channel. The channel is narrowed to 65 ft. wide at the lower end, thereby using up a portion of the velocity head, and is lined with 6 in. of concrete on gravel to prevent erosion from the high velocities.

Bids were taken in April, 1919, and a contract for $58,887 awarded to John T. Walbridge Engineering & Contracting Co., of Chicago.

The material in the dam is compacted clay taken from excavation in the side hill, which excavation forms the spillway channel. A concrete conduit and gate house are located near the center of the earth embankment. The conduit was used to take care of the ordinary stream flow during construction and now carries the pipe lines to the pumping station. There were no floods to speak of and the work was carried through with practically no delay. The dam is now finished and water stands within about 4 ft. of the spillway. Bids for a filter plant will be taken in a few weeks.

The final costs on the dam are as follows:

Earth fill, 28,453 cu. yd., at 50 ct.	$14,226
Stripping 3,104 sq. yd. at 60 ct.	1,862
Excess spillway excavation, 3,517 cu. yd. at 40 ct.	1,406
Core wall, 1,666 cu. yd. at $2.00	3,331
Conduit and gate house	9,300
Slope paving, 4,000 sq. yd. at $2.50 and 1,123 sq. yd. at $2.00.	7,754
Spillway $21,000, less 5,313 cu. yd. at $9.00	16,218
	$54,099

Cost per 1,000,000 gal. of storage capacity = $12,560.

Decatur Dam.—In Decatur, Ill., the need for additional water supply has been recognized for the last 8 or 10 years. The extreme dry weather flow of the Sangamon River there is almost nothing. The problem was to remedy this condition by the construction of a storage reservoir.

Preliminary investigations and action by the city council had settled the location of the proposed dam. The storage required, the type of dam and spillway capacity were items requiring extensive study.

A thorough investigation of the entire problem was made and a considerable amount of field work done. The maximum flood on record in the Sangamon River at Decatur occurred in 1913 and was found to be approximately 21,500 sec. ft., equivalent to 25 sec. ft. per sq. mi. from the tributary area of 862 sq. mi. Assuming a 5 ft. depth overflow, a spillway 500 ft. long would be required. The earth embankments will be 13 ft. above the crest so that the spillway will safely pass a considerably greater flood.

The amount of storage required was determined from local conditions, which made it feasible to provide a total storage of about 9.0 billion gallons, yielding an average daily flow of about 40 million gallons per day.

Various types of sections for the spillway were studied and it was finally decided to adopt a concrete gravity section. Borings indicate a reddish brown clay for the first 10 ft. with alternating layers of gravel and sand for 10 to 40 ft. Below this is an 8 ft. layer of clay, and below this, more sand.

The dam is designed to reduce the velocity of percolation, and thereby prevent undermining, by the provision of a sufficient length for the enforced percolation. This is accomplished by means of steel sheet piling, a broad base, and upstream and downstream aprons. Under the spillway section round bearing piles spaced 3.25 ft. center to center are used. The crest of the spillway is 500 ft. long and 28.5 ft. high, while an additional 2 ft. of storage may be obtained by a movable crest. The foundations are also designed to stand an increase of 5 ft. in the height of the spillway. Two 9 ft. x 14 ft. flood gates, and a 4 ft. x 4 ft. flushing gate are incorporated in one end of the spillway. There are also two 36 in. water pipe connections, one of which is reserved for future use.

The earth embankments are 13 ft. above the crest, as previously stated, and are 1,200 ft. long, being cut approximately in two by the concrete section.

The effect of the reservoir formed by this dam will be noticeable 12 or 15 miles upstream.

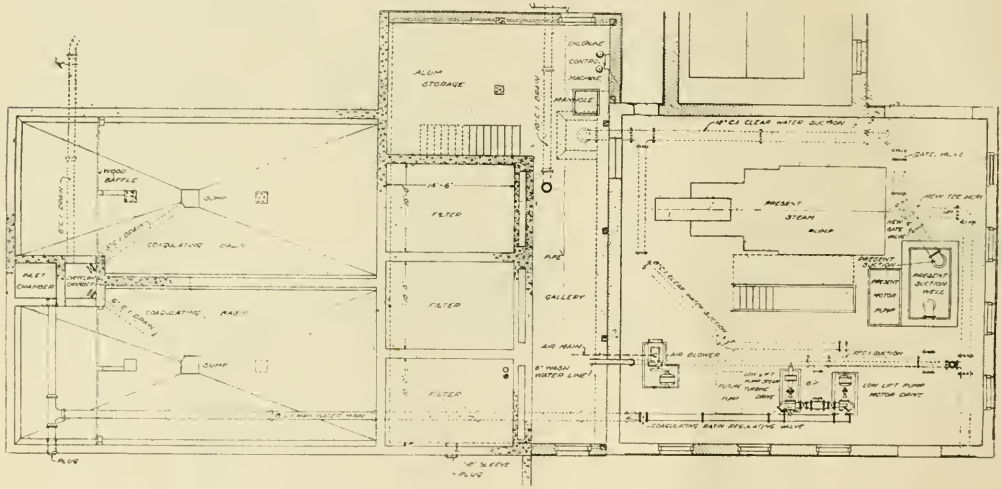
The cost of the entire project is estimated at $1,250,000, including land. Bids for this work will soon be advertised so that the construction may get an early start this spring.

Dubuque, Ia., to Have City Manager.—The citizens of Dubuque, Ia., by a majority of 831, voted in favor of adopting the city manager form of government.

Compact Rapid Sand Filtration Plant at Hawkesbury, Ont.

A compact 1,000,000 gal. capacty filter plant has recently completed its first 6 months of operation at Hawkesbury, Ontario, a town of 5,500 population on the Ottawa River, near Montreal. A description of this plant appears in a recent issue of the Contract Record. The plan is an excellent example of simplicity in small units and yet it appears to be complete in all the essential details. The following excerpts from our Canadian contemporary will illustrate the main features of the plant.

The filter plant consists of several distinct and related parts, viz., low lift pumps, coagulation basin, chemical solution tanks and chemical feeding devices, filters, pipe gallery, operating floor, chemical storage, and clear water basin. The coagulation basin, clear water basin, filters and chemical storage tanks are constructed of reinforced concrete. The concrete used where watertightness was required was composed of one part cement, two of sand and four of crushed stone. No waterproofing material was used to secure a tight job. The superstructure over the filters, operating floor, and chemical tanks is of brick.



Sectional Plan Illustrating Compactness of Rapid Sand Filtration at Hawkesbury, Que.

The low lift pumps consist of two direct connected Allis Chalmers centrifugal pumps, each having a capacity of 750 gal. per minute against a head of 30 ft. One pump is driven by an electric motor and the second by a steam turbine. The low lift pumps take their water from the intake well through a 10-in. suction and discharge into the inlet chamber of the coagulation basin through an 8-in. cast iron discharge line. The discharge of the low lift pumps is regulated by a double disk valve actuated by a 30-in. float. This regulating valve is located on the discharge line. A stem connected with the valve disks passes through two stuffing boxes and connects with the float, the float chamber of which is connected with the coagulation basin by a 1½-in. line thus maintaining the same water level in the float chamber as obtains in the coagulation basin.

The two chemical solution storage tanks, each with a capacity of 620 gal. are located on the operating floor level. The piping and fittings in connection with the alum solution tanks are of acid proof bronze or lead.

The alum solution from the storage tanks is measured through lead-lined orifice boxes and is applied to the raw water in the discharge line from the low lift pumps. A secondary coagulation treatment is also provided to the already treated water directly in front of the outlet of each section of the coagulation basin.

The coagulation basin is in two sections, each section being 40 ft. long by 18 ft. wide by 16½ ft. deep. A storage or retention period of 3½ hours is provided by the basin when the filter plant is operated at its rated capacity of 1,000,000 gal. per day. The alum-treated water enters the basin from the inlet chamber, passes down toward the bottom of the basin and under the baffle placed near the inlet end of the basin and then flows to the outlet flumeway. Each section of the basin is provided with two 14 in. diam. sluice gates into the outlet flume and one 6 in. drain. The end of each drain line is located in a sump and the control valves are located in the dry or overflow chamber adjoining the inlet chamber. An 8 in. drain line leads from the dry chamber to the bank of the river, where it connects with the 10 in. sewer line from the filters.

The basins are covered with 30 in. of earth.

The three filter units each have a filtering capacity of 240 gal. per minute. The strainer system of each filter consists of the 6 in. manifold, the lateral pipes and strainer valves. The manifold pipe is provided with 2 in. connections on each side spaced 10¼ in. apart, into which are placed the cast iron lateral pipes. The lateral pipes are drilled and tapped on one line every 6 in., to receive the composition metal strainer valves. After installation the manifold system was imbedded in concrete to the top of the lateral pipes.

On top of the manifold system is placed 9 in. of graded gravel, varying in size from 1 in. to ⅛ in. Directly above the gravel is located the air manifold system which consists of the 2½ in. air pipe drilled and tapped every 4 in. on both sides to receive the ⅜ in. brass air tubes. These air tubes are slotted on alternate sides every 2½ in. and are connected at both ends with the air pipe. The 27 in. of filtering medium is placed on top of the gravel and air manifold system. The filtering medium consists of two parts filter sand and one part crushed marble, the marble being of the same size as the sand.

Each filter unit is equipped with the necessary filter piping, loss of head gauge, and rate controller. The rate controller is of the Venturi type and each controller is so arranged that it can operate separately or in series with the other controllers, control in the latter case being provided by the master controller.

The filter bed is washed with air and water simultaneously, as the air and wash water are supplied through separate manifold systems. In washing the filter the air is shut off about one minute before the wash is completed to allow the wash water to level the filtering medium.

The pipe gallery is located on the ground floor and in front of the front wall of the filters. In it is located all the necessary piping, valves, loss of head tubes, and rate controllers. Adjoining the pipe gallery is the chemical storage room where sufficient space is available for the storage of a car load of filter alum.

The clear water basin is located below the filters and pipe gallery and has a capacity of about 50,000 gal. On the side of the clear water basin adjacent to the pumping station is located a sump in which is placed the end of the suction line to the high lift pumps. Also at this point the chlorine is supplied to the filtered water to effect sterilization. A clear water depth gauge with high and low water alarm is also provided.

Water for washing the filters is taken from the 12 in. line to the 100,000 gal. service tank, through a 6 in. cast iron pipe connecting with the wash water line to each filter.

A Wallace and Tiernan manual control pulsometer type chlorine control apparatus is provided to chlorinate the filtered water as it passes from the clear water basin to the high lift pumps.

Work on the filter plant was started in September, 1918, and completed in June, 1919.

The cost of the filter plant, including the low lift pumping equipment, was $49,100. The contract was awarded to Archambault & Le Clair, Montreal, with the Norwood Engineering Co., Cowansville, Que., as sub-contractors for the filter equipment. Jas. O. Meadows, sanitary engineer of Montreal, acted as engineer for the town, with Victor Belanger as resident engineer.

Methods of Grouting Pressure Tunnels of Catskill Water Supply System

Grout was used extensively in the structures of the Catskill water supply system of New York City for filling spaces behind the lining of tunnels, for cutting off the flow of water into shafts and tunnels by grouting the water bearing fissures, for solidifying the foundations and stopping the flow beneath dams, and for various other purposes. The experiences and results obtained in this grouting are summarized by James F. Sanborn and M. E. Zipser in an 80-page paper* presented Feb. 4 before the American Society of Civil Engineers. The matter following is abstracted from the paper:

The utilization of the pressure-tunnel type is one of the notable features of the Catskill Aqueduct. There are nine pressure tunnels, aggregating 35 miles in length. These tunnels were driven in rock, deep beneath the surface, and were lined with concrete averaging from 18 to 24 in. and more in thickness. They have a finished inside diameter varying from 16 ft. 7 in. to a minimum of 11 ft. The depths of the tunnels below the surface vary from 100 ft. to a maximum of more than 1,100 ft., the latter being the depth of the Hudson River crossing. The hydraulic gradient at this crossing is more than 1,500 ft. above the invert of the tunnel.

It was the opinion of some authorities that the concrete lining could not be made tight enough against ground-water heads. It was also feared that where the rock was porous and water-bearing, excessive leakage might develop when the tunnel was put in service, and that the application of pressure in the case of jointed and fissured rocks might even cause movement of the rock and rupture of the concrete lining, with resultant outward leakage. Great reliance, therefore, was placed on the use of grout to make the tunnels secure and tight against all leakage.

Grouting in pressure tunnels was done in two stages: (1) Low-pressure and, (2), high-pressure grouting. The purpose of the low-pressure grouting was: (a) primarily to fill the void spaces between the lining and the rock, particularly above the arch, and, at the same time, to form a blanket over the construction joints in the arch; (b) to fill the voids in the dry packing where the latter was used; and (c) to fill any porous or honeycombed spots in the concrete.

The object of the high-pressure grouting was: (a) To cut off the leakage of water into the tunnel and thereby prevent the escape of water out of the tunnel by filling with grout, forced in under high pressure, the crevices and openings in the surrounding rock; and (b) to complete the filling of the voids between the lining and the rock, particularly in the high places in the roof, and between the drip-pans and the rock. In general, the procedure followed in grouting was first to grout the space above the arch under low pressure through the pipes set for the purpose, and then to grout, under high pressure, the vent pipes and weepers.

Details of Low-pressure Grouting.—The details of the low-pressure grouting differed somewhat on the various contracts, the following description being typical of the procedure as finally developed. When a stretch of tunnel was ready for grouting, the usual practice was first to grout the arch pipes, beginning at one end of the stretch and working toward the other. The pipe to be grouted was first raked out in order to clean it of any obstruction; sometimes, it was blown out with air to clear it. Plug cocks were placed on all pipes to which connections were made. A 2-in. grout-hose connection, equipped with a side vent, was attached to the pipe to be grouted, and batches of grout from a tank grouting machine were then discharged through the hose and into the pipe, by compressed air. The pressure ordinarily used for this groutings was about 75 to 90 lb. per square inch.

Grouting was continued at each pipe to which connection was made until the pipe refused to take more grout or until the grout had traveled along the roof several hundred feet ahead, when connection was made with another pipe and the process repeated. The distance which the grout above the arch could be forced ahead of the pipe, varied from 200 to 300 ft., and, in some cases, where there was a large continuous void space in the roof, it would travel more than 500 ft. It was the usual practice, however, where conditions were normal, to grout the space above the arch by making connections to the roof pipes every 125 to 200 ft.

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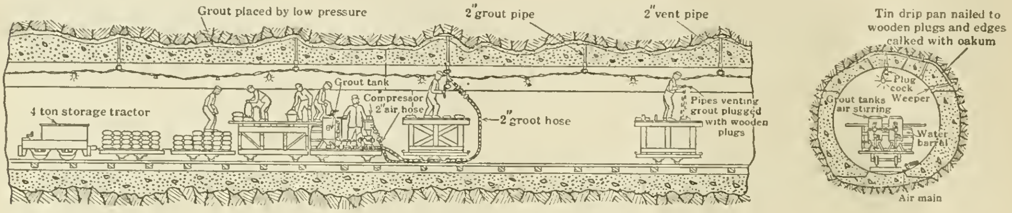
*Grouting Operations Catskill Water Supply. Proceedings American Society of Civil Engineers, Vol. XLVI, No. 1, January, 1920, pp. 1-80.

In charging the grout tank the cement, sand, and water in proper proportions were placed in the tank, and the air was allowed to boil up through the batch to agitate it, while, at the same time, the batch was generally stirred by a hand paddle, as the air alone was insufficient to mix the materials thoroughly.

As the batches of grout were forced into the pipe and the grout flowed ahead, water in large streams issued from the adjacent roof pipes; this was the excess water from the grout, as well as the ground-water leakage which had collected above the arch. This water was pushed ahead of the grout, and as soon as the pipes showed a flow of grout they were plugged either by driving tapering pine plugs into them or, as in the case of the vent or other pipes to which connection was to be made for high-pressure grouting, they were closed by means of the plug cocks at the ends. In some cases, the holes for the connections were plugged by driving a wad of oakum back into the far end of the pipe. At the end of the shift, or several hours after grouting, when the grout had partly set, the oakum was removed with an auger. Any pipe which had filled up with grout that had set, was drilled out for the subsequent grouting.



Arrangement of Plant for Grouting in Lower End of City Tunnel.

During low-pressure grouting, the high vent pipes were kept open to drain off the excess water, to permit the escape of air, and to prevent the accumulation of ground-water pressure. During the grouting, the transverse joints in the arch and any porous spots in the concrete generally showed a seepage of water first, then very thin grout appeared, after which, the leaks usually stopped in a short time, and silted up. In some cases, the leakage of grout and water through the joints was stopped by driving thin wooden wedges into the joints, and leakage through the porous concrete was stopped by bracing and wedging a board covered with a mat of oakum against the porous spot. The longitudinal joints on either side of the key at the top of the arch also leaked in a few stretches, due principally to porous concrete in the vicinity of the joints.

The weepers from drains and drip-pans, and the deep-seated pipes were also kept open during low-pressure grouting. The matter of proper grouting is of the greatest importance in securing good results, because it is essential not to permit the building up of a ground-water head on the fresh grout since the object is to form an impervious blanket over the top of the arch and thereby prevent leakage of water through the unset grout and the formation of channels through the transverse and longitudinal construction joints or through any porous spots in the concrete.

Proportions Used for Low-pressure Grouting.—A batch of grout consisted of 1 bag of cement weighing about 95 lb., 1 bag of sand weighing generally about 80 to 90 lb., and from 6 to 8 gal. of water, the total making a batch of about 2.0 to 2.2 cu. ft. of liquid grout measured in the tank. The cement was the ordinary commercial brand used for the concrete lining. The sand was very fine, screened when necessary to meet the requirements of the specifications, namely, that 100 per cent pass a sieve having 64 openings per square inch, 45 per cent pass a sieve having 1,600 openings per square inch, the wires of the sieves being, respectively, 0.035 and 0.013 in. in diameter. In the work north of New York City, glacial sand was used, while for the City Tunnel white quartz beach sand from the south side of Long Island was obtained.

The quantity of grout placed depended on the excess breakage in the roof and the exent of the dry packed spaces. In the City Tunnel, in unsupported stretches, where no dry packing was used in the roof, the quantity of grout placed under low pressure varied from 4 to 9 cubic feet per lineal foot of tunnel.

Progress in Low-pressure Grouting.—The progress in low-pressure grouting varied, usually from about 600 to 1,000 ft. of tunnel a week, working three shifts a day. Many factors influenced the speed, such as the length of haul, the delivery of materials, the proficiency of the gang in loading and unloading the cars, etc., and, of course, the volume of space to be filled above the arch. Usually, in normal stretches of tunnel, not more than one or two connections were made in 24 hours. The sand and cement were hauled through the tunnel to the grouting plant on flat cars holding from 20 to 30 bags. The sand was brought to the work in bulk, but was bagged by hand at the top of the shaft before it was sent underground. Tests were made of handling the sand in bulk in the tunnel, but it was soon found that a package of about the same size and weight as a bag of cement was the most convenient form for rapid handling.

The force employed in the tunnel for low-pressure grouting was generally one foreman and seven or eight men, two charging the grout tanks, one stirring the batch, one operating the valves on the grout tank, and three or four handling the hose and making the connections. On the surface, men were employed to bag the sand and load the cars on to the cages.

Precautions to Be Observed in Placing Low-pressure Grout.—Low-pressure grout should be injected gently under as low a pressure as possible to avoid churning of the mix and separation of the ingredients, and only a sufficient quantity of water should be used to produce a freely flowing mixture that will not clog the hose. The air pressure should not be higher than necessary to force the grout through the hose and into place. A reducing valve was used on some parts of the work to cut down the line pressure from 90 to 40 and 30 lb. per square inch. An excess of air, especially when injecting grout under water, is likely to agitate and churn the mix, causing separation and stratification of the sand and cement, with the formation of a soft deposit of laitance at the top of the grout in contact with the rock.

To avoid the after blast of air when grouting a space filled with water, it was the usual practice to close the discharge valve before the hose "kicked," the latter requiring careful watching. A further precaution used to prevent the separation of the mix where a large space filled with water was grouted, was to keep the grouting connection from 2 to 3 ft. below the top of the grout.

The importance of venting the high pipes and allowing all the weepers to run freely during low-pressure grouting has been referred to. It sometimes happens that low-pressure grout enters the drip-pans or drains, but in such cases the pipes should not be kept closed to allow the accumulation of ground-water pressures.

In stretches showing general seepage in the roof of the tunnel, taken care of by drip-pans and pipes, it was sometimes found that the panning was not entirely successful in preventing the water from mingling with the grout. At first, it was thought that these wet stretches should not be grouted with the drier stretches on either side, and they were skipped on the first trip, but it was found that better results could be secured by grouting the wet stretches in the roof with the rest, as the water in the wet stretches did not accumulate pressure, but would travel over the top of the dense unset grout to open vent pipes, sometimes a long distance away, instead of breaking through the grout blanket at a point of nearby weakness.

The purpose of the high-pressure grouting, as already stated, was to complete the filling of the voids between the lining and the rocks, and, more particularly, to cut off the flow of water into the tunnel by forcing grout into the water-bearing seams and closing up all openings in the surrounding rock, in order to prevent or reduce the leakage out of the tunnel when the latter is in service.

Details of High-pressure Grouting.—It was the general practice first to grout the high vent pipes in the roof, in order to complete the filling of the space above the arch, and then to grout the pipes from the drip-pans and the deep-seated pipes leading to the rock seams. Some of the vent pipes in the roof showed a flow of water in stretches originally dry. The grouting of one vent pipe would often stop the flow of water from another, indicating a flow of grout through the open seams in the rock. In other cases there would be an increase in the flow of water from a weeper due to forcing water through the rock seams to an open vent. As a rule, very little grout could be injected into the vent pipes.

After grouting the arch pipes, the "wet" pipes, or weepers, were next grouted. In starting operations, air at 100-lb. pressure was blown into the pipe to expel the water from the drip-pans or seams. This was sometimes followed by a charge of water to clear the pipe just prior to grouting. The charge of water was often applied as a test to give an idea of the circulation of grout to be expected. If the charge of water failed to "go," the pipe would take very little grout. Another indication of the size and extent of the rock seams that could be reached from a connection was the showing of air at another open pipe or the refusal of the pipe to take air when high pressure was applied.

The usual practice was to grout the weepers with a mix of 1 bag of cement and 5 to 8 gal. of water. When the pipe would take no more grout, the high pressure, about 300 lb. per squure inch, was kept on it for from 5 to 10 minutes, which had the effect of squeezing the water out of the grout and packing the cement solidly in the pipe. Frequently, if this procedure did not completely fill the pipe, it was drained and plugged with a thick batch of grout. Temporary plugging of a seam during grouting was often overcome by forcing air into the seam under high pressure.

It was found difficult to shut off small leaks through pipes set in the lower portion of the side-walls where no vents were provided. After a pressure of 300 lb. per square inch had been maintained on these holes for several minutes, it was often found that no grout had been forced in the pipe and the leak still continued. Such pipes were successfully closed, even in the case of those which flowed several gallons per minute, by driving a tight-fitting wooden plug into the extreme end of the pipe and then ramming with dry cement.

It was the practice on some parts of the work to complete the high-pressure grouting on all the key pipes in the arch in a stretch of tunnel, after which the tunnel was gone over a third time when the flowing pipes were grouted.

Air Pressures.—The pressure used for high-pressure grouting varied, as a rule, between 250 and 350 lb. per square inch. This was the pressure at the grouting tank. It had to be sufficiently high to overcome the ground-water pressure and, in addition, to force the grout into the seams in the surrounding rock. In the case of very fine seams, the frictional resistance is so great that it is doubtful if much grout is injected into them even under high tank pressure.

Gauge measurements of the rock-water pressure were often taken before the grouting of a flowing pipe was started. The gauge readings, however, gave no clue as to the quantity of grout the pipes would take. The gauge pressure showed that the rock-water level at the pressure tunnels had dropped considerably below the original ground-water level, the gauges registering pressures usually under 100 lb. per square inch, so that the back pressure was not generally high and the grout was forced in under high net pressures. In many cases, the entire ground-water head was restored a few weeks after the completion of the high-pressure grouting. The grouting of a wet seam in the Hudson River Tunnel has already been referred to. At this location, the ground-water pressure before grouting was 475 lb. per square inch, and the grouting was done under pressure running up to a maximum of about 700 lb. per square inch.

Mix and Consistency.—To insure the flow of grout into the fine openings, neat cement was used in high-pressure grouting. The consistency of the mix varied, depending on the conditions. Ordinarily, 1 bag of cement and 5 to 8 gal. of water were used. Where grout could be forced into the rock seams it was mixed very thin—as thin as ¼ bag of cement to 30 gal. of water. If this mix was taken freely, it was regarded as an indication that the grout was traveling some distance from the tunnel lining and, therefore, was not of much value. The mix was accordingly thickened gradually by increasing the quantity of cement in the batches until the pipe began to refuse grout, when thin grout was again injected, the pipe being finally plugged with a batch of thick grout under 300-lb. pressure.

It was originally contemplated to use very finely ground cement for grouting in order that the grout might be carried readily into the finest seams. However, cement of ordinary fineness of grinding was used, as it was realized that, in time, the openings outside the tunnel lining and through the body of the concrete would silt up. Experiments show that the finer the grinding, the greater the loss in the strength of the grout on account of the more thorough hydration of the cement. The coarse particles impart strength to the cement, and, for that reason, very fine grinding may not be desirable. Some tests were made under severe conditions, using quick-setting Lias lime, but the results were not satisfactory, as the material did not harden properly and the water was not cut off.

Precautions to Be Observed in High-pressure Grouting.—A very important factor in successful grouting is the control of the consistency of the mix. For large openings, thick consistencies should be used, while for the very finest openings the best results are obtained with thin grout. The thick mixes, however, must carry enough water to prevent undue clogging. No coarse particle or lumps of cement must be allowed to go into the tank. The cement is sometimes affected by the dampness of the tunnels and should be screened when necessary. Grouting of a hole must be continued without an interruption long enough to clog the hose or permit an initial set of the grout.

Time Required for Grouting and Quantity of Grout Placed.—The time required for grouting the pressure tunnels varied, depending on the method and equipment used, the length of haul, the extent of the space grouted, and the quantity and distribution of inward leakage. Table I and the following data give the progress, force employed, power consumption, and other facts relating to the grouting in the two miles of tunnel included in Section 8 of the City Tunnel, in the lower part of New York City. This portion of the tunnel was comparatively dry, there being no large, concentrated flows within the two miles. The air used for grouting was supplied by a compressor at the top of one of the shafts. The plant and equipment used for grouting on this part of the work are shown in Fig. 6.

TABLE I—DATA ON PRESSURE TUNNEL GROUTING, CONTRACT 67, SECTION 8.

Finished Diameter of Tunnel, 11 and 12 ft.

	Low-pressure grouting; one grouting outfit.	High-pressure grouting; one grouting outfit.
Linear feet of tunnel grouted	10,313	10,313
Connections to grout pipes	170	1,683
Eight-hour shifts worked	72	116
Batches of grout placed	23,298	2,888
Quantity of liquid grout placed, in cubic yards	1,761	153
Quantity of grout per linear foot of tunnel, in cubic yards	0.17	0.02
Progress per week, in linear feet of tunnel	2,690	1,467

The total force employed in the tunnel and on the surface, averaged 42 men on each shift during the low-pressure grouting and 34 men per shift on high-pressure grouting, for two grouting outfits.

The electrical power consumed by the compressor, hoist, lighting, pumps, and tractors aggregated approximately 7,800 kw-hr. and 5,300 kw-hr. per 1,000 ft. of tunnel on low and high-pressure grouting, respectively, covering two grouting outfits.

The cost to the city, of grouting, based on contract prices. averaged $5 per lineal foot of tunnel, on Contract 67.

Equipment Used in Grouting.—Tank grouting machines of the Canniff type were used almost exclusively for grouting. These machines are very simple in construction and operation, consisting essentially of a tight cylinder provided with suitable pipe connections for introducing compressed air and for mixing and ejecting the grout. The tanks are very compact, weigh about 500 lb. when empty, and have no moving parts to wear out and be replaced. They are, therefore, particularly well suited for tunnel work. Both thick and thin mixtures can be used in them, and they are equally well adapted for high and low-pressure work. They are very efficient where large quantities of grout have to be placed.

A slight advantage of the Canniff tank is found when grouting fine seams under high pressure, or placing small quantities of 1:1 grout. As the process is necessarily slow there is a tendency for the cement, but more particularly the sand, to settle in the bottom of the tank and clog the openings. The use of very thin grout usually overcomes the difficulty.

As a rule, two grouting tanks were operated simultaneously in grouting the tunnel, one being charged while the other was discharging. For high pressure work, however, it was the usual practice to use only one tank. The two tanks were mounted either alone on a low flat car, or at one end of a platform car which was large enough to hold, in addition, from 20 to 30 bags of sand and cement. In some cases, an upper platform was also provided for materials. The materials were hauled through the tunnel by mules or motor trucks. The water for mixing was measured either by pails, or automatically by a tank placed at the side or above the grout tanks. High-pressure armored hose about 25 ft. long was used for grouting purposes. The plant used for grouting on the work at the lower end of the City Tunnel is shown in the sketch.

Operation of Grout Tanks.—The usual method of operation during low-pressure grouting, was first to put into the tank the required quantity of water, then to let the air into the tank at the bottom, which agitated the water, and then the cement and sand were put into the tank and stirred by hand with a wooden paddle, as it was found that the air was too slow for mixing and was also wasteful. When thoroughly mixed, the door at the top of the tank was closed, the air was then admitted at the top, and the liquid grout forced out through the grout hose into the pipe connected to it. The air was then turned off quickly.

Unless care is taken to close the air discharge valve the instant the last of the grout leaves the tank, an after-blast of air follows the grout, resulting in stirring it up and causing separation of the materials, and also tending to form air pockets in the space grouted. The men operating the tanks, however, soon become skilled in controlling the discharge. As an added precaution, the air-pressure gauge on the grout tank was watched closely to note the fall of pressure as the grout discharged, and the emptying of the tank was also indicated by the "kick" of the grout hose when the charge left it.

In some cases the following scheme was tried. The air valve was closed as the batch of grout started to leave the tank, permitting the air in the tank to expand and force the grout through the hose. This method, however, was slow and was not generally used. Where the grout displaced water, the ejection of the grout by expanding the air in the tank was quite effective in cutting down the after-blast of air. The tanks could be operated very rapidly. As much as 1,500 batches of 1:1 grout, equivalent to about 115 cu. yd., were placed in 24 hours, using two tanks. This process involved the handling of about 135 tons of cement and sand in the 24 hours.

High-pressure Air Compressors.—The air for operating the grout tanks was obtained by connecting to the air line laid in the tunnel, the air pressure in the line being usually from 80 to 100 lb. In order to provide the pressure required for high-pressure grouting, small Westinghouse direct-acting single-stage air compressors, known as "boosters," were generally used. These compressors, mounted on the same car with the grout tanks, took suction from the main air line and delivered air in the tanks at a pressure of 300 lb. per square inch. The compressors weigh about 500 lb. They are provided with air gauges registering up to 450 lb. per square inch. A spring relief valve, capable of being set at any pressure up to 400 lb., is placed on the main discharge. Each branch of the 2-way discharge is supplied with a stop valve, a check valve and air emergency stop valve, so that it may be closed automatically by a sudden release of pressure due to the bursting of hose or any other reason.

Independent Air-generating Plant in Tunnel.—The grouting in the tunnel necessitated the maintenance and operation of the large compressor plant used for tunnel driving and the relaying of the air pipe line in the tunnel, which had been taken up during the placing of the lining. In order to avoid the use of the expensive main air plant some of the contractors used small independent portable compressors in the tunnel, driven by gasoline or electricity, and mounted on cars traveling along with the other equipment. These compressors were used both for the low and high-pressure grouting.

On tne work in the northern portion of the City Tunnel, low-pressure grouting was carried on with three rigs, each consisting of the following equipment: One 30-h.p. electric motor; one Ingersoll-Rand 2-stage, belt-driven air compressor, capable of delivering 170 cu. ft. of free air per minute at 100 lb. pressure and 130 cu. ft. at 350 lb.; one geared pump, with a capacity of 50 gal. per minute driven by a 7½-h.p. electric motor; two grout tanks, two water tanks, a platform car for making connections to the grout pipes, and a platform mounted on two flat cars for the cement and sand. For high-pressure grouting the same rig was used, the compressor being adjusted to deliver air at 300 lb. per square inch.

Grouting by Air and Water Pump.—In the Hudson Tunnel, where it was necessary to use grouting pressures of 700 lb. per square inch, a combination of air and water-pressure pump was devised. A Canniff tank was partly filled with grout which was placed under a pressure of about 300 lb. by a Westinghouse booster connected as usual with the tank. Water was then pumped into the tank through another connection by a high-pressure Cameron pump, reducing the volume of air above the grout so as to raise the pressure to 700 lb. per square inch, if desired. The discharge valve of the tank was then opened, and the pump was kept going in order to maintain the pressure while the grout flowed slowly into the space back of the lining. This arrangement worked very successfully. The advantage of a pump with a steady flow lies in the fact that there is no after-blast of air forced through the grout.

Paddle Mixing Machines.—In a few cases, paddle mixing machines which mix the grout mechanically instead of by air, were used. The results obtained by these machines are good when they are new, but the moving parts and the stuffing boxes soon give trouble on account of wear. The bad feature of both the air-stirring grout tanks and the paddle mixing machines is the blast of air which follows the discharge of grout. As already noted, it is very important to control the discharge of air in grouting in order to secure good results.

Grouting Pads.—The specifications called for the use of grouting pads for forcing grout into any porous concrete in the lining. These pads consisted of a steel casting measuring about 1 ft. by 2 ft. 3 in., containing a rubber gasket, and mounted at the end of a 5-in. extra heavy wrought-iron pipe. In using the grout pad, it was jacked against the porous spot in the lining by screw-jacks at the other end of the column, and the grout was then forced into the pad to impregnate the concrete. These pads were not successful, as they were clumsy to handle, the area covered by the pad was too small for effective work, and the gaskets would blow out. After a few attempts, their use was given up.

Only a few porous spots occurred in the concrete lining through which grout leaked during low-pressure grouting, and it was found that the most effective method of treatment was to wedge a board faced with oakum against the porous spot. The flow of grout soon stopped and the opening closed up.

Indiana Sanitary and Water Supply Association Convention.—The next annual convention of the Indiana Sanitary and Water Supply Association will be held on March 8th and 9th, 1920, at the French Lick Springs Hotel, French Lick, Ind. An exceptionally attractive program is being prepared. Special rates are offered by the hotel management to those attending the convention, and it is advised that reservations be made in advance when possible. The convention opens at 9:30 a. m., March 8. L. R. Taylor, French Lick, Ind., is secretary of the Association.

100 Reasons Why Cities Changed from Private to Public Ownership of Utilities

Reasons for changing from private to municipal ownership are set forth in a pamphlet issued recently by Burns & McDonnell, Consulting Engineers, Kansas City, Mo. The causes given are based on actual personal reasons expressed by reputable city officials, on observations of Burns & McDonnell as engineers during the time when negotiations for change of ownership were in progress and on actual results obtained by cities after acquiring public utilities. The reasons as given by these engineers are reprinted below.

1. The paramount difference in principle is: With private ownership, "profits first"; with municipal ownership, "service first."

2. When a municipally owned utility makes profits the taxpayer and citizen reaps the dividends in better service, cheaper rates and oftentimes reduced taxation.

3. Fort Smith, Ark., municipal waterworks in 1915, cleared $40,041. Part of surplus used in retiring bonds against plant. Taxpayers, instead of foreign capital, received dividends.

4. No corporation, community or concern has a monopoly on the brains or ability to successfully operate a public utility.

5. The waterworks of Council Bluffs, Ia., in 1910, under private ownership, showed receipts of $106,614; operating expenses, $61,994. In 1916, under municipal ownership, the receipts were $153,904 and operating expenses $57,196.

6. The loyalty to service, ambition to succeed, desire to excel and efforts to please are quantities equally strong, regardless of the ownership of the utility.

7. It is realized that intelligent public officials can do equally well what the private corporations have heretofore done for a profit.

8. Everett, Wash., in first year of municipal ownership of waterworks, made a net profit of $6,260, after paying operating expenses, bond interest and setting aside proper amounts in the depreciation and sinking funds.

9. As profits accumulate beyond an amount required for maintenance, interest, depreciation and reserve, the rates are reduced in the municipal plant, thus declaring dividends to the public instead of dividends to private investors.

10. Omaha, Neb., in 1917, reduced water rates 50 per cent to more than 90 per cent of the consumers, after acquiring plant in 1912.

11. The promise of dividends to the investor in utility stock and his insistent clamor for dividends, frequently results in an impairment of service.

12. The order "dividends first" from headquarters often delays to the point of danger many important improvements that are recognized as urgent by the local manager.

13. Poor service in 75 out of 100 cities has been the fundamental cause which led to change of ownership.

14. Cleburne, Tex., before municipal ownership, never had sufficient water, and at times no water. Since owning and improving plant the water supply has been ample at all times.

15. Water purification plants add to operating expense, thus reducing profits, hence, most of our modern water filtration systems are municipally owned.

16. Impure water more than any other one thing, is the cause of high death rates. Many municipalities have reduced their death rates from 75 to 92 per cent by introduction of pure water supplies immediately following municipal ownership.

17. Council Bluffs, Ia., water plant, under city ownership, furnishes a water with a reduction of 50 per cent of the bacteria count and 263 per cent of turbidity in comparison with the water supplied during the last year of private ownership.

18. One Kansas municipality had its business growth checked, its industries paralyzed and its population in constant fear, because of their alarmingly high typhoid death rate. In 10 years, since acquiring the property by the city, about 30 per cent increase has been made in the revenue, the consumers increased about 30 per cent and the typhoid death rate decreased 70 per cent.

19. Oshkosh, Wis., since acquiring the waterworks, has laid by a surplus of $39,315, from the earnings to apply to the building of a filtration plant.

20. Billings, Mont., pleaded, coaxed and litigated for years with its owner of the water plant to abandon or purify its water supply. One year after the city took over the plant by a 5 to 1 vote for city ownership, the purification plant was in operation. The state board of health now reports the water pure, wholesome and free from pathogenic bacteria.

21. Billings, Mont., in the first five months of operation under municipal ownership, cleared $10,682 above costs of operation, interest on bonds and depreciation charges.

22. These actual cases are typical of dozens of other cities. If the municipal authorities are to be held responsible for the health conditions, they should have complete ownership and control of the water supply, which is the most important factor in the health, growth and prosperity of any city.

23. The health of a community, which is in proportion to the purity of its water supply, is safer in the hands of a nonpartisan water board of local business men than in the hands of one individual who may reside thousands of miles away, with no civic or community interest.

24. The record of the water rates of the cities that have changed ownership shows that within two years after changing, a reduction of 27 per cent has occured.

25. Not being primarily concerned in "profits first," the municipal plants often make lower rates to larger users, thus encouraging the developing of new industries.

26. Of the 25 largest cities in the United States, all except two have municipally owned waterworks, and one of these—San Francisco—is now constructing its own supply.

27. Where municipally owned utilities exist, the suburban additions and districts are developed, thus avoiding congested districts.

28. This development of outlying districts with their lower land values, makes possible the ownership of homes by the poorer classes, and the improvement of suburban country estates by the wealthier classes.

29. The freer use of water, light and heat in municipal plants, for wading pools, swimming pools, gymnasiums, skating ponds, fountains and for park purposes, places that city in a position to outdistance its less fortunate competitor in the race for commercial supremacy.

30. In one city that recently changed ownership, a new, well-lighted park, with fountains, wading pool and aquarium not possible under the terms of the franchise, and its prohibitive rates, were soon acquired under municipal ownership.

31. The results and successes of municipal ownership of other cities have started the municipal ownership ideas in many places.

32. Boonville, Mo., in 1904, bought privately owned waterworks for $52,000. The present plant, with improvements and extensions, made out of earnings, is valued at $90,000. Outstanding bonds, $4,000 to be retired in 1920.

33. Cleburne, Tex., under municipal ownership of the waterworks, reduced insurance rates from 79 ct. to 26 ct., which resulted in a saving of $30,000 a year in insurance premiums to the citizens.

34. First quarterly report at Beaumont, Tex., after purchasing waterworks, showed a net profit of $1,212 above all costs of operation, maintenance, including interests and sinking fund charges on a $500,000 bond issue.

35. Boonville, Mo., in 15 years of municipal ownership of waterworks, has made a net earning of $50,000 over all operating expenses, including maintenance and depreciation charges.

36. In Kansas there are only 12 privately owned water plants out of 225, and three of these are now being appraised for purchase by the municipality.

37. Nebraska has over 150 city owned waterworks and only six privately owned.

38. Minnesota has over 200 municipal and seven private water systems.

39. Iowa has nearly 300 municipal plants, with only 18 privately owned.

40. Even the most radical advocate of private control has conceded that the city streets, bridges and viaducts are within the province of municipal ownership, but why must the utilities under the paving, such as water, gas, sewer or conduit, be owned by another?

41. A municipality that can handle its paving, parking and acquaducts, ought not to be prevented from using its own city water for washing its paving, its city water for beautifying its parks and its own electricity for lighing and making safe all the improvements already owned and constructed by the city.

42. An inspection of viaducts, streets and parks at night tells the story of whether gas and electricity are sold by a company or by the city. Many a dark street has its bridges and viaducts with ornamental lights in name only. They reflect no light or glory, either, and stand only as a disgrace, often broken down or dismantled.

43. As an insurance policy against crime, no safer policy was ever written than that of well lighted streets and alleys.

44. Can you imagine about how long a merchant would last in business without adequate lighting facilities? Cities are nothing more than big competitive merchants and the city, with its streets, buildings, viaducts, parks and boulevards properly illuminated, has a tremendous advantage in commercial supremacy.

45. The completion of appraisals of several sewer systems in Texas, where private ownership of this important utility exists, has brought to light some important facts, showing conclusively that private ownership of sewers is detrimental to the public health.

46. Two cities are located in Texas having the same population—of about 20,000 each—one has its municipally-owned sewers serving every home in the city, with 33 miles of pipe. The other has a privately owned system of sewers, consisting of 9 miles of small diameter, shallow-laid line, serving only the best improved districts and incapable of extensions. It does not require a sanitary expert to say which of the two cities is the most desirable place to live.

47. The sewer connection fee and the monthly charge for each faucet and toilet as charged under private ownership of sewers, acts as a penalty toward better and cleaner living conditions.

48. In many cases the rental charge for sewer services for two years on an average 5-room modern cottage will pay the cottage owner's share of the construction cost of municipal sewer system.

49. By carrying out reasonable sanitary measures and providing its own adequate sewer facilities, a community protects itself and sets a good example for others.

50. All public utilities which are natural monopolies, and which by their nature are necessary to the welfare and happiness of the people, should be under municipal ownership and operation.

51. The most noticeable contrast between public and privately owned water systems is the fire protection and inadequate domestic pressure in higher levels. Many cities have experienced needless fire losses equal to the cost of the entire works.

52. The usual first step taken by cities after acquiring ownership of water plants, is providing adequate mains of larger diameter, closer spacing of hydrants and increased pumping facilities. In one plant appraised the average increased carrying capacity required in the mains was 85 per cent; another was increased 18 per cent immediately after acquiring ownership.

53. Companies desiring revenue without assuming responsibility for fire protection, have added miles of 2, 3 and 4-in. pipe (a practice seldom followed by municipal works where revenue is secondary to service).

54. The rapidity with which all utilities have changed ownership is in itself evidence of the more satisfactory results obtained under municipal ownership.

55. Statistics now show more utilities in the hands of receivers than ever before. This means poor and interrupted service. The resumption of service and the improvements required are in many cities being accomplished by the cities having the properties appraised and taking them over.

56. A city's credit is always better than an individual's credit. In one city that acquired a utility recently the 5 per cent municipal bonds for its purchase sold at par, while another utility privately owned was offering its 7 per cent securities at 90 cents on the dollar.

57. This utilizing of the city's own good credit means less price for light, power, gas, water or other utility service.

58. Investors are seeking municipal bonds, while private utility securities are a drag on the market even at their alluring discounts and interest rates.

59. The old charge of making the municipal utility a political football has ceased to exist, for the real shrewd politician finds that the best politics he can play is to give service to the public.

60. The superintendent of four municipally owned utilities in Virginia, Minn., with its water, light, gas and steam heating, reports after 5 years of municipal ownership: "Our board is non-partisan, our rates were not hiked during the war."

61. Council Bluffs, Ia., reports after 10 years of municipal ownership of its waterworks, that politics and the constant interference of politicians with city affairs ceased when the city took over the works, and that if all our utilities were municipally owned, politics would be a lost art.

62. The elimination of politics and the substitution of good service is the result not of abstract theories, but of experience and the actual needs and demands of the public.

63. Municipal ownership, as a rule, provides better working conditions, shorter hours and better wages, thus fewer labor troubles ensue. Strikes in municipal plants are practically unheard of.

64. Chicago, Ill., made a net profit of $3,003,200 on municipally owned waterworks, with rates about one-half those usual under private ownership, with the highest wages and best labor conditions of any similar plants in the country.

65. We would not think of placing our fire and police departments under private ownership for profit. These are for the protection of property. Then why have our water departments operated under such conditions? This is the most important factor in the development of the health and prosperity of a community and the protection of life.

66. There is a greater tendency toward a fair and impartial rate schedule under municipal ownership. In a water plant recently taken over, it was found that many favored customers were receiving special rates, while others were paying a much higher rate for the same service.

67. This special rate matter is one of the ways in which political favors and influence for rate legislation are sought.

68. Under war conditions, while nearly all private owned utilities were clamoring for increase in rates, 85 per cent of municipal plants maintained their rates, and nine actually reduced them.

69. The best governed cities in the world are the cities where there is most municipal ownership. When a city takes over its utilities it removes the incentive to corruption.

70. Municipal ownership tends to distribute the wealth and power of a community and increases the democracy in the industrial and civic life of the people.

71. During the last year, several American cities have taken over their street railway systems, and many others are now engaged in appraisals with similar objects in view. McGraw's Station List for 1918 shows 35.5 per cent of all lighting systems in the United States are municipally owned.

72. The municipal street railway system of San Francisco has made a true net profit of over $1,000,000 in first five years of operation.

73. Detroit, Mich., has reached agreement with street railway company on purchase of the property. The city wants to make sure of adequate and reliable transportation facilities.

74. Cleveland, O., has demonstrated the success of municipally owned street railway system.

75. "A franchise is a prize for bad government," is a statement which can be attested to by many communities.

76. Mr. Francis J. Heney, in a public address in Kansas City, February 5th, 1912, said: "After five years of investigating the causes and cure for graft, I bring this one message: I am driven to believe that the public ownership of public utilities is the only cure for graft."—(See Kansas City Times, Feb. 6th, 1912, page 1).

77. Official investigations have disclosed that the campaign funds of the dominant political party and not infrequently of both parties, have been derived to a considerable extent from public utility interests.—(Report of National Civic Federation on Municipal and Private Operation of Public Utilities, pp. 28-39, 41-42.)

78. Greenville, Tex., of about 10,000 population, having a municipal light plant, comparing its service and rates with

cities of a similar size, but having private owned utilities, showed a saving to the tax payers of $116,756 per year, or nearly enough to rebuild the plant every two years.

79. The number of municipally owned light plants has increased from one in 1881 to 1,609 in 1917, and there are many more now. The per cent of municipal plants has increased from 9.5 per cent to 32 per cent of the total.

80. The result of seven investigations of several hundred light plants showed the average rate for private plants $0.1007, and for municipal plants $0.0868, or a difference of 16 per cent in favor of the municipal plant for the same class of service.

81. The results of ten investigations of several hundred light plants showed the maximum rate for private plants $0.114 and for municipal plants $0.0873, or a difference of 31 per cent in favor of the municipal plant.

82. The results of five investigations of several hundred light plants showed the average cost per arc light per year as $89.95 under private ownership, and $59.92 under municipal ownership, or a difference of 50 per cent.

83. The Civic Federation in its 1907 report on the Chicago plant, concluded that from 1887 to 1905 the cost of electric lights used by the city was $743,494 less under municipal ownership than it would have been under private ownership, and in six years, from 1907 to 1912 after power was taken from the drainage canal, the city saved over $4,000,000 on street lights alone, when compared with the rates charged by the private companies.

84. Pasadena, Calif., had a 15 ct. light rate with private ownership. This was reduced to 12½ ct. during the agitation for municipal ownership, and reduced to 5 ct. within two years after municipal ownership.

85. In Pasadena, Calif., within 8 years after municipal ownership, street illumination had been increased 956 per cent, while the area of the city had only been increased 20 per cent, and the total cost of street light increased only 219 per cent.

86. The saving to the people of Pasadena, Calif., in reduced cost of light and power up to July 1, 1916, or a period of 8 years, has been estimated at over $1,000,000. The total cost of the plant and system up to that time was $486,240, and its invoiced valuation $840,434.

87. In 20 years the Kansas City, Kan., light plant will have charged off as depreciation, the entire capital value of the plant and will have retired from earnings, all bonds against the plant. The city still will be owning a well equipped light and power plant, as a result of the policy of using surplus earnings for plant betterments and extensions. That is contrary to the rate making plan of public utilities, which is to keep capital value high for the purpose of procuring rates.—(Statement of Certified Accountant.)

88. In the city of Holyoke, Mass., in 12 years of municipal ownership, the citizens saved $1,431,333 in light and power bills, $301,326 in street lighting; and $474,159 in gas bills; or a total of nearly $2,250,000, as compared with what they would have paid at the rates offered by the private company.

89. At Springfield, Ill., after combining their water and light plant, the interest or rates of return on the money invested in the light and power plant was 21.9 per cent, while the rate of return on the total investment in the waterworks was 9.9 per cent.

90. At Seattle, Wash., in 1902 the citizens were paying 20 ct. per k.w. hour for electric current. The agitation for a municipal plant was followed immediately by a reduction to 12 ct. Other reductions followed after the city plant was built and operated in competition with the private plant. The Seattle plant is earning dividends in addition to the earnings of the plant itself, of at least $1,000,000 annually in reduced rates caused by this competition.

91. That municipal ownership improves labor conditions is attested to by the fact that labor organizations are almost unanimously in favor of municipal ownership.

92. Virginia, Minnesota, has made its third reduction in light rates since buying the lighting plant.

93. Richmond, Va., owns its gas, water and light plant. The gas is sold at 80 ct. per 1,000 cu. ft. This gives a net profit of $271,869, although the plant is maintained in high-class condition and has paid for itself many times over out of the profits. The city still charges interest, depreciation and taxes against the plant, totaling $123,052, leaving net profits of $148,817.

94. Richmond, Va., has owned its gas plant since 1852. Since that time it has reduced rates, paid for itself out of its earnings and turned into the city treasury over $1,500,000.

95. The average rate charged by municipal gas plants in Virginia in 1917 was $1.09. The average rate for private plants was $1.27. In Minnesota the average municipal rate for gas was $1.28 and the average private rate was $1.40.

96. "It is the consensus of public opinion here that the city was wise to build the gas plant, and nobody wants a change to private ownership."—R. E. Ludwig, Director of Public Utilities at St. Petersburg, Fla.

97. "I will say that in my opinion the municipal operation of the gas plant has been very satisfactory to the citizens, in that it is furnishing gas at a very low rate, much below the average for cities of this size at the present time. We have not raised our rates during the war times."—D. A. Reed, manager Water and Light Department, Duluth, Minnesota.

98. "An alderman seldom has had sufficient experience and legal training to prepare a franchise himself, and in the absence of some consistent theory of franchise policy, he has permitted the attorneys for public service corporations to draft the franchises they wanted and present them for his approval."—D. F. Wilcox.

99. "In the Cleveland gas case the evidence showed that the company was paying cash dividends of $1,440 a year on each original investment of $1,000, besides stock dividends amounting up to 1892 to a total of $24,000 for each investment of $1,000."—(Parsons).

100. "Real public ownership is the very essence of democracy."—Prof. Frank Parsons, Boston Law School.

Municipal ownership of public utilities has been demonstrated to be successful. A word of advice, however, should be offered. Before undertaking to vote bonds for a municipal plant of any character where a private plant is already in operation, competent engineers who are experienced in appraisal work should be consulted.

No municipality should make the mistake of trying to establish a competing plant. Where a private utility already occupies the field, it is by all means advisable to purchase it at its fair appraisal value, as the first step toward municipal ownership.

Cost of Out Door Meter Installations at Terre Haute, Ind.

The Terre Haute, Ind., Water Co., for outdoor meter installations, has been using recently a pit made of two 2½-ft. 20-in. vitrified sewer pipes with a slot in the bottom of the lower one to fit over service pipes laid some years ago before the present rules concerning the depth of the services were in force. These pipes are provided with a Clark cover and coupling yoke. The cover is 6 in. high, making the total depth of the installation 5½ ft. The average cost in 1918 of an installation of this type including service pipe from the main to the curb was $42.27, according to a paper by Dow R. Gwinn, president of the company, in the January Journal of the American Materials Association. The itemized cost of the installation as given by Mr. Gwinn is as follows:

Corporation cock, ⅝ in.	$ 1.09
Curb cock, ⅝ in.	1.66
Brass tail piece, ¾ in.	.38
Extra strong lead service pipe, 3 lb. per foot, 17.1 ft., ⅝ in.	3.72
Service box with 2½ in. shaft	1.50
Labor, 10.9 hours at 35 ct.	3.82
Labor, 2.2 hours at 40 ct.	.88
Drayage	1.25
City permits	.87
Overhead on tools and equipment	1.30
Total for services	$16.47
Empire meter, ⅝ in.	$12.00
Tile, 2	3.70
Clark cast iron cover	2.75
Meter yoke	1.50
Pipe and fittings	.93
Cement	.37
Labor, 5 hours at 35 ct.	1.75
Labor, 2 hours at 40 ct.	.80
Drayage	2.00
Total for meter and installation	$25.80

Hexagonal Chart for Finding the Velocity of Water in Pipes

By C. WARRINGTON ANTHONY, Bahia Blanca.

From Water and Water Engineering, London.

The exponential formula is very much used nowadays in hydraulic problems dealing with the flow of water in pipes and sewers. Many charts have been drawn to represent each formula, some taking a variable co-efficient into account, which depends on the nature of the inner surface of the conduit; but I have never seen one made that does equally well for all the exponential formulæ. For this reason I have designed a hexagonal chart (Fig. 1) that takes care of six variable quantities, the velocity of flow, co-efficient of roughness, hydraulic means radius and slope, together with the powers to which these last two quantities are raised and yet, in spite of all this apparent complicacy, is as easy to handle as a chart made for working out only one kind of exponential formula. Evidently a chart of this description will prove of great value, since it may be used for rapidly computing and comparing results obtained from a given case by applying different formulæ. It may also be used to deduce the best equation to fit in with the results of experiments that have actually been carried out.

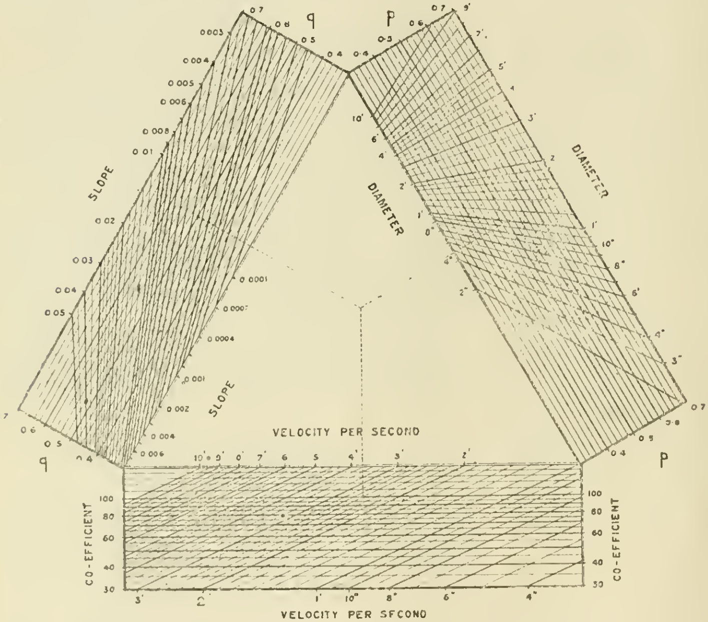


Chart With Three Binary Scales for Finding Flow of Water in Pipes.

The exponential formula is usually written: $V = C\ (D/4)^p\ S^q$, or $V = C\ R^p\ S^q$, since the hydraulic mean radius of a pipe flowing full is the fourth part of its diameter. There will be seen to be three binary scales in Fig. 1, arranged in the form of an equilateral triangle. The coefficient and velocity go together on one scale, and the diameter and slope together with their respective powers on the other two scales. The way the diagram is used is illustrated with dotted lines for the following case: diameter 1 ft., slope 0.0025, coefficient 100, $p = q = 0.5$. The velocity is seen to be 2 ft. 6 in. per second.

When using the chart it is convenient to have a hexagonal transparent index with its sides parallel to the three index lines. By placing a straight-edge against one side, the index lines may be moved without changing their orientation or displacing the one parallel to the straight-edge.

The great beauty of the chart lies in the fact that it does not contain a single curve, which makes it much easier to draw and ensures a high degree of accuracy. This is attained by employing logarithmic instead of equally spaced coordinates.

Sewerage Practice in the Emergency Fleet Corporation Housing Projects

In the housing projects of the Emergency Fleet Corporation standard methods in the design of sewerage projects were adopted and used as much as possible. Some of these standards should be of practical use in similar work. A paper by C. P. Collins, engineer of sewerage and drainage for the U. S. Shipping Board, read before the recent convention of the American Society for Municipal Improvements, describes these methods, and the following notes are from his paper:

In the work of the Emergency Fleet Corporation's housing projects, certain co-efficients of run-off were adopted as follows: For roofs, 100 per cent if directly connected with the sewers and 90 per cent if directly connected with the gutters. For pavements, 90 per cent if of asphalt, concrete and other dense pavements, brick, stone block, etc., with close joints; and 60 per cent if blocks with wide joints. For roadways, 40 per cent for macadam, 30 per cent for gravel, and 25 per cent for hard earth. For sidewalks, 90 per cent for those extending to gutters and 60 per cent for those separated from the gutters by parking. For lawns, parking and open spaces 20 to 35 per cent. For meadows and cultivated areas, with various slopes and surface conditions, 1 to 20 per cent.

In designing the grades and sizes of storm sewers, a velocity of 3 ft. per second was adopted by the engineering branch as the minimum velocity, and 12 in. as the smallest diameter for any sewer receiving rain water. The velocities and capacities were calculated by use of the Kutter formula, using a co-efficient of roughness of .013 for vitrified pipe and .015 for pipe or concrete and similar materials, vitrified pipe being used for sizes up to and including 24-in. and concrete for larger sizes.

In determining the average rainfall co-efficient, a study was made of a typical block which indicated that the streets, roofs and walks occupied 30 per cent of the entire area, driveways 9 per cent and grass plots and gardens the remaining 61 per cent. It was assumed that a co-efficient of 90 per cent would apply to the streets, roofs and walks, 30 to the driveways, and 15 to the grass plots and gardens; this giving an average run-off co-efficient for the entire area of 0.4. On account of the slope of the ground, it was estimated that the time of concentration of flow at inlets would be eight minutes. In both this and the emergency housing designs, the time of flow in the storm sewers was calculated from the slopes and size of the sewers. In this case also the sewer flow was calculated from Kutter's formula with a value for n of .013 for vitrified pipe and .015 for concrete.

In designing the house sewers for these projects, the engineering branch generally allowed for an average flow of 90 gal. per capita per day, with a maximum flow in laterals of four times the average and in mains of 2¾ times the average. The grades were required to be such as would theoretically produce a velocity of 2 ft. per second when the sewer is running full or half full. This required a minimum grade of 0.42 per cent for 8-in., 0.30 per cent for 10-in. and so on up to 0.08 per cent for 24-in. At dead ends and summits, however, a grade of one per cent was required for 8-in. sewers or else a special arrangement for flushing was provided.

Statistical Experts Wanted.—U. S. Civil Service Commission will hold open competitive examination to secure statistical experts at $3,600 to $4,500 per year.

SCIENCE OF MANAGEMENT

Application in Civil Engineering and Construction Fields

The term Science of Management was coined by the editor of Engineering and Contracting and first used in "Cost Analysis Engineering" (1908) and explained more fully in "Cost Keeping and Management Engineering" (1909). The last named book, which contains ten laws of management and many subsidiary principles, was the first book on the science of management. In the columns of this journal many additional laws, principles and detail methods of management have been published. This section, which appears weekly, may be regarded as a serial sequel to the two books above named.

Administration and Organization on Construction Work

By ARTHUR G. GEHRIG,

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Engineering administration and organization has been a very potent factor in the progress of all construction work ever since the earliest days of engineering, but it was not until the last few years that any particular attention has been paid to this important subject. In fact this one subject has practically become a separate division of engineering and competent men are now devoting their entire time to this branch of engineering service. It requires alert men to determine the proper methods to be carried out in order to secure the best results, and it also requires caution to prevent laying too much stress upon administration and organization, for there are cases where work has been highly systematized at the expense of other essential considerations.

The notes which follow have been garnered from both current literature and from personal experience. In many cases definite incidents are set forth to emphasize the principles which they well illustrate. Most of this discussion applies to a construction job on which there would be employed from 200 to 500 men.

Perhaps the most important principle that should be borne in mind to secure the proper administration of a project is that, from the chief engineer, or engineer in charge, down to the office boy there should be a definite ranking and a specific succession of responsibility. This ranking of employes does not infer, or even permit, the snubbing of inferiors, but it should require that proper respect be shown superiors, and obligates the superiors to be worthy of such recognition. In other words, the man in charge should always be ready to talk with his subordinates, but yet he need not be regarded as "one of the boys."

Each man in the office and field should have some definite thing to do and he in turn should be held solely responsible for the performance of that task. When there is a chance for shifting responsibility, there is often shiftless work. In addition to the effect produced by a man knowing that he will be held responsible, there is also the result that he will take pride in his work—feeling that he alone has been entrusted to do it. Then if anything does go wrong there is no difficulty in placing the blame upon the proper one and making the discipline suit the needs of the case.

Many times the office work can be handled much more easily if a schedule is made of the routine matters. It is quite common to find the office force over-worked just at the end and at the beginning of the month. Much of this work can be done just as well at the middle of the month as at the end, if some one will only "break the ice" and change the old system. For instance, the monthly estimate may just as well be made up on the 20th of the month as on the 30th, or the progress report may just as well run from the 15th to the 15th as from the 30th to the 30th. A considerable saving in office expense can usually be made by distributing the work uniformly over the month. The schedule is also valuable to check against to prevent overlooking some of the routine reports until several days after the time when they should have been sent in.

Punctuality in the office in the field is just as important as it is in the office in the big city. The office hours should be identical with those of the workmen so that any information or attention which the men or foremen may need will be available at any time. It is discouraging to say the least when a foreman wants certain plans or checking lists, and after walking a long way to the office, finds that the office force has not yet arrived. Again, in case of serious accident to any of the men it is imperative that some one of the office force be on hand to aid in taking care of the injured. To maintain the proper spirit in the office force it is also just as essential that the office be closed promptly, otherwise the men will go at their work in a half-hearted fashion feeling that they have to work overtime anyway. Of course there will be times occasionally, in case of some emergency, when it is necessary to work overtime but such overtime should be reduced to an absolute minimum.

On large jobs, time-saving devices will often effect a great saving in both office and outside work. All letters and other reports which do not contain too much tabulation or sketching should be gotten out on a typewriter. A good adding machine will pay good interest on the investment from the beginning and will save its original cost several times over before it is worn out. Not only does it save time but it saves nerve energy for other things which cannot be done mechanically. On a large job which is scattered over considerable area, a small private telephone system of three or more phones will often save a lot of time at comparatively small cost. In other cases where telephones are not available, speaking tubes have been used. These have been put up, and used satisfactorily on high travelers. To accomplish a similar purpose large megaphones are commonly used to communicate to points beyond the range of ordinary conversation.

After the office routine has been established, it is desirable to have each man become pretty well acquainted with the work of one of the other men so that he can take up the work immediately and intelligently in case the other is kept from the work on account of sickness or other reasons. Many times the office work is entirely upset and thrown into confusion when one man is sick for a week. This is simply because no other man knows anything about the details of that portion of the work. When the office force is kept just as small as possible, a handy man who is apt at figures can often be used to good advantage outside and called into the office to help make up payrolls at the busiest time in the month. If no regular material man is employed, such a handy man is also useful in checking materials and supplies as they are unloaded, or put into the structure.

All planning of the methods for doing the work should be done in the office and not by the foreman out on the job. The foreman may be resourceful enough to attend to this in pretty good shape, yet his time can be put to better use in directing the men, and the planning is logically the work of the engineer. Even if the foreman does plan the work, the engineer must give his thought and attention to the matter to see that the scheme is satisfactory. He may as well, therefore, attend to the planning in the first place and relieve the foreman. This does not mean, however, that the engineer shall not listen to any suggestion which the foreman may wish to offer. The engineer should always be ready to receive suggestions which may aid him in making his decisions.

Shipments of permanent materials, or supplies, when received, should be carefully checked so that any shortage may be ordered replaced immediately. If the material has been checked as received, but is short when the time comes to use it, the responsibility for loss can be fixed more definitely than if the material had not been checked upon its receipt. Not only should shortages be noted, but also damaged materials should be noted and claims made against the carrier immediately. Damaged parts may then be repaired and be ready for use when required, thus avoiding delay in construction.

No man should attempt to do work for which he is not fitted, not even for a short time. Such practice often leads to serious accidents, as is shown by the following incident: Although the full crew of men was at the job, the foreman was overly anxious to get a bundle of ties picked up. He got up on the 25-ton derrick car and started the engine. He had asked the inspector to run the swing lines. The bundle of ties weighed less than a ton, but the inspector got the swing lines mixed up and one of them broke. The long boom swung around at right angles to the track and in less time than it takes to tell it, the derrick car had upset and rolled to the bottom of a 20-ft. embankment. It was merely good fortune that no lives were lost. This little affair cost the contractor about $1,500, not to mention delay to the work and the delay to the traffic of the railroad. This might have been avoided if the regular men had been called upon instead of new men trying to do something that was out of their line. At other times I have seen timekeepers try to run locomotive cranes or locomotives when there was no need for such action. This sort of practice should never be tolerated.

If possible, monthly estimates should always be presented to the other party for approval or check before being sent to the head office. This often saves a lot of correspondence and allows small adjustments or explanations to be made in the field which would be very hard to take care of after the estimate had been mailed in to the main office. The monthly estimate is not a report which can be made with extreme accuracy and it is, therefore, advisable that the approximation be satisfactory to both parties concerned. As stated before, it matters little at what time of the month this estimate is made up.

Supplies should always be purchased in large quantities so that the cost of handling may be reduced to a minimum. I have known a foreman to send a man two miles for one dozen hack saw blades once or twice a week when several gross were used on the job. In many cases the cost of materials is also less in large quantities. Generally speaking, the quality of supplies should be of a moderately good grade. Poor coal is poor economy. The same is true of many other contractor's supplies, such as packing, waste, oils, etc.

The tools and materials should at all times be kept in an orderly manner so that no time is lost hunting for things needed at once. It is all too common a sight to see an engineer go to the tool shed and spend 20 minutes pawing through a large pile of pipe-fittings and valves to find a 1-in. tee, and then after having found one, spend 10 minutes more in disconnecting it from several other fittings.

Foremen are improving in this matter of orderliness but there is still a lot of room for more improvement along this line. Needless to say, supplies should be ordered long enough in advance to arrive in time not to delay the work. Yet we see items overlooked many times until the last minute when they are needed.

Accurate records of costs of all principal parts of the work should be kept up to date. These should, in general, be reduced to unit costs so that an estimate may be made of the amount required to finish the job. However, one is often misled by unit costs compiled early in the progress of the work, because they are very likely to be lower than the final unit costs which will include the cost of cleaning up, freight away from the job, transportation of men, etc. The unit costs compiled during the progress of the work are also valuable in pointing out certain portions of the work which are costing too much, or which were bid too low.

Where there are several foremen on a large job, every effort should be put forth to maintain harmony between them at all times, and also that the several parts of the work are progressing according to the same schedule. That is, one foreman's work should not delay that of another. If there is a tendency in that direction, his gang should be increased, or the other foreman's gang should be decreased.

On one large job the resident engineer called a weekly meeting of all the foremen to discuss the plans for the coming week. The idea worked out very well and the foremen seemed to show an interest in these meetings and in each others' work.

If two foremen, working near each other, are continually bickering, one or the other should go regardless of how good a foreman he may be. Together they are a detriment to the progress of the work and of no good influence upon the workmen. Likewise the workman who is a chronic kicker and who is always passing new rumors about the job has no place in a good organization. The sooner he is discharged, the better. Even though he be a good workman he is an expensive man to have around. The loud mouthed foreman who can be heard a quarter of a mile cursing his workmen is also getting to be a thing of the past.

The size of the gang which a foreman can properly look after depends greatly upon the character of the work. If the gang is well scattered over a building, a dozen to twenty may be all that one man can look after, whereas in such work as track shifting or grading, where the men are bunched up and all in plain view, one foreman may easily handle 50 or 60 men effectively.

Night work as a general rule is not economical so far as labor itself is concerned. That is, even if a man is not paid a higher rate at night (and he usually is) that labor is more expensive because a man will not perform as much work in one hour at night as he would in one hour during the day. There are cases, however, where night work is economical when considering the job as a whole. When night work will avoid the payment of a large penalty, or when it will avoid delay to a large portion of the other work, or when it may prevent a disaster, such as might result from a flood, it is the most economical thing to do. In one other case night work is advisable. When very expensive equipment, such as a wrecking outfit, is being rented it is more economical to pay the higher labor cost than to pay the high rental for a longer period of time. Of course it is the common thing to make repairs to large pieces of equipment at night so as not to take them out of service and tie up the gang during the day.

In choosing men for the different parts of the organization in the field a considerable amount of good judgment is required to find the best places for the many different kinds of workmen who are available. A steam-fitter has no place up on a high bridge or steel building even though he be willing and anxious to work there. Old men, of course, should be kept near the ground, and new men should be worked into dangerous positions gradually.

The selection of watchmen on large jobs is of extreme importance, and especially so if there is any threatened danger from the unions. It may not be necessary to have time-clocks to check up the watchmen yet it is essential that they be looked after at unannounced times to see that they are actually on the job and awake in every sense of the word. A really good watchman may become lax in time if he is never proven. It is an encouragement to him if his superior comes around and finds him on the watch. He will take new pride in his trust and try to continue it.

It is well to detail some reliable and competent man to look over the larger and more expensive equipment periodically to see that all of the smaller parts, which might not otherwise be noticed, are in good condition. A very small part in an out of the way place may be the cause of an expensive accident. One foreman accidently discovered that one of the sheave pins in a large traveler had been nearly cut in two, unnoticed, because it had not received the oil which had been applied regularly. After that he delegated the signal man to go over all of the sheaves of the masts and booms at noon each day to see that none were cutting badly, and to oil them. This did not require more than 15 minutes each day but it was a valuable precaution for one sheave pin failure would probably have meant a serious accident and an expensive delay.

A great improvement in the work of the men may sometimes be obtained by changing the hours of starting and stopping work. When men are working an 8-hour day and do not have to travel a great distance, they usually prefer to work early in the morning rather than late in the evening. And the employer will get more for his money if he will allow the men to do this. It is much better to work the men from 6:30 a. m. to 3:30 p. m. than from 8:00 a. m. to 5:00 p. m. This allows them to work in the fresh of the morning when the air is cool, and, when their strength is greatest. The early quitting hour also gives better opportunity for home work and for clean, wholesome social activities.

Men should not be required to walk a great distance to the work. Means should be provided to carry the men to and from the work or a camp should be established at the site. If a man has to walk a couple of miles to the job, he is pretty well tired out by the time he starts work and the employer is not getting full value for his money.

The men should be well disciplined in regard to certain things, one of which is regularity in coming out to work. A man who lays off two or three days out of every week should be discharged without further reason. He cannot be depended upon when he is needed, and further than that, if one man can be irregular and hold his job others think that they may also do the same. Soon the men will work just when they please (excepting those who are hard pressed financially) and the work will suffer greatly.

Drunkenness is another habit which will grow among the force until it greatly hinders the work, unless it is strictly curbed from the beginning of the job. Of course it is not expected that a force of "tee-totalers" can be had, but it is possible to discipline the men so that their drink will not interfere with work. The few who cannot be so trained can easily be spared. The practice of getting men out of jail so that they can come to the job is a demoralizing one. If a man's unpaid wages will get him out of jail every time he gets in, he is likely to get in quite often. It is also a poor policy to advance men money (except in cases of distress) before pay day. Nine times out of ten the money is used to no good purpose and the request is repeated before the next pay day arrives. When pay periods cover a half a month, or a whole month, there is no advantage in holding the pay until Saturday night to avoid drunkenness interfering with the work. If a man is paid in the middle of the week and is not sober the next morning after one night's drinking, he is not any more likely to be sober on Monday morning after drinking a whole day and two nights. After trying both plans, there seems to be no advantage whatever in the Saturday night pay as far as the work is concerned. From the point of view of the workman's welfare, it is a positive detriment to him.

Fortunately, the enactment of the national prohibition law will tend to greatly reduce drunkenness and petty crimes that often get workmen, and sometimes foremen, into trouble.

In organizing the forces and in making the general layout of the plant and temporary buildings every effort should be made to shorten distances and to keep the material moving in the same general direction as much as possible all the time. The office, tool-houses, storage sheds, etc., should be centrally located. All small miscellaneous work should be done under cover as much as possible. A very cheap roof can be put up to afford a considerable working space. This is very useful in rainy weather and will generally save in labor several times its cost.

When the work can be done either upon the ground or in a yard, it is generally more economical to do so in preference to doing the same work up in the air or out on the structure.

When scaffolds are necessary they should always be put up by the men who are to use them. This will insure their being put up carefully, and in case of accident to one of the men using them, it is a great legal advantage to know that the injured person helped to erect the scaffold. On some jobs scaffolds are built by one gang for use by another gang. This is bad practice and should never be allowed.

If a long delay in the construction can be foreseen, there comes the important question whether the present work shall be completed and the organization disbanded, or shall the present organization be reduced to such an extent that the present work will continue until the future work starts. This depends upon many factors. Is there other work for the men and equipment to go to? How valuable is the personality of the present organization? What is the duration of the probable delay? Can the present organization be brought back together again? These and other similar questions have to be answered before an intelligent decision can be made.

There are many other subjects which have a proper place under the general topic of engineering administration and organization. Some of these may be enumerated welfare work, pension system, motion timing, competition, rivalry, new appliances, premium work, etc. All of these are important factors in the administration and organization of different enterprises, but space does not permit a full discussion of all of the above subjects here.

Piece Work System of Payment for Meter Readers

A piece work system of payment for meter readers and other classes of employes is successfully employed by the Montreal Light, Heat & Power Co., of Montreal, Que. The scheme was described by Mr. J. A. A. Beaudin of the company, in a paper read at a recent meeting of the Canadian Gas Association. The following is an abstract of his paper:

The service of public utilities involves the performance of numerous routine operations in the consumer's home by various categories of employes operating individually and without supervision. The reading of meters in situ, the delivery of bills and collection notices, and the collection of arrears are a few of these operations. Until recent years, and even nowadays, the general practice has been to remunerate employes engaged in these various tasks on a flat or fixed rate salary, based either on the hour, day, week or month, with additional privileges (in many cases) respecting sickness, holidays, etc.

Disadvantages of the Salary System.—This mode of remuneration makes possible the payment of wages for labor which has been only partially supplied, and since the actual supervision of his work is impracticable, the employe is tempted to take advantage of this condition occasionally, if not regularly, to limit his activities, and the means he may use to conceal his shortcomings are only limited by his ingenuity and his morality.

Furthermore, an employe working under this system of remuneration is inclined to complete indiscriminately each task as he encounters, without any regard whatever to the amount of time and expense involved—i. e., he will often devote an unwarranted amount of time to straightening out a difficulty which if reported to the office could be handled much more expeditiously and economically by an expert. In other words, a worker on a fixed salary does not by-pass difficulties—he leaves no residue.

Piece Work Assumes Handling Maximum Number of Cases in Minimum of Time.—The piece-work or commission system keeps the employe at his work, insures the full employment of his time, limits his absences from duty, prevents the payment of unearned wages, and regularizes the output—it helps get the work done regularly and systematically, but it leaves a residue.

The piece or commission worker is interested in handling a maximum of cases in a minimum of time, so naturally the tendency is to handle the straight-going jobs and by-pass difficulties whenever encountered, no matter what the employer's interest; the employe's interest is in the opposite direction, as every stop he makes to overcome difficulties limits his wages, hence while this system has removed the necessity for outdoor supervision, it has created a demand for closer indoor supervision over the work performed, and the piece-work system must be supplemented by a faithful follow-up system of by-passed jobs, without which it would prove a failure and cease to be economical and practical.

The piece-work system only works advantageously in districts where the clientele is dense or semi-dense; it is not effective in districts where the clientele is scattered. The piece-worker is entitled to a supply of work commensurate with his capacity, and his work requires to be properly sorted and routed so that he may carry it on under advantageous conditions. The employer's interest also demands this in order to keep the piece-work rating at a minimum and at the same time afford the employe an opportunity of earning a fair remuneration thereunder. Failure to give proper attention to this detail would result in the establishment of a higher piece-work rating than would otherwise be necessary.

Employes of the same category should all be on an equal footing and be given equal opportunities. They should permute periodically from one district to another in order that one and all may cover each district and the entire system in a given period. All districts do not afford similar or equal opportunities and no one should be allowed to work continuously in either a good, poor or medium district, but all should have their turn in each.

The piece-worker, although not a tracer, a trouble straightener or a worker fitted to operate in scattered districts, must be efficient and capable of discharging his duties in a competent manner and carrying to a satisfactory conclusion all work entrusted to his care. While he is quite within his rights in by-passing real difficulties and not spending his time in conducting long searches, etc., he must positively not be allowed to by-pass for trifling causes any of the work entrusted to him.

Piece-Worker Must Be Assured of Sufficient Work.—It is not desirable to limit the activities of a piece-worker with a view to securing work of a higher standard, as he cannot fairly be retained in service without sufficient work to keep him employed, and even if allowed to go off duty as soon as he has performed his limited task, he will work just as hastily in order to get through and go off duty, and the employer's very object—viz., to cause him to move more slowly and perform work of a better quality, will be defeated; furthermore, the resultant limitation of his earning power is likely to cause the piece-work rating to go up. An energetic piece-worker with a large working capacity will earn "record" wages when supplied with unlimited work and will indirectly contribute to the maintenance of an economical and moderate piece-work rating. Furthermore, the employee who earns large wages will have every inclination to perform his work in accordance with instructions—his very interest in his position is the best guarantee to be wished for in this connection. A proper inside supervision over the work involved in the completion of by-passed jobs, as reported by the piece-worker from time to time, affords the employer a still further protection. This inside supervision is a most important feature of the piece-work system and must be exercised with constant vigilance.

Operation of Piece-Work System as Applied to Meter Readers.—We supply gas and electricity and issue part of our bills on a bi-monthly basis and part on a monthly basis. The ordinary gas and electric lighting consumers are billed bi-monthly, while the larger consumers and all electric power users are billed monthly. Our territory is divided into meter reading districts and the work distributed in accordance with schedules, so that the readings repeat themselves on about an even calendar date in each district. Twenty-two men take care of our meter reading on a piece rating per meter. These men work five days per week on regular readings; every Saturday morning is devoted to each man "picking-up" the readings which he has passed by for various reasons during the current week. This "picking-up" work is done at the regular rating for current readings. After the completion of this "picking-up," the residue of by-passed readings reported to the office represents only such cases as present unusual obstacles. The fact that each meter reader must appropriate a certain amount of time to "picking-up" his own by-passed readings is an added protection against by-passing for trifling causes. When reading meters in a district where the clientele is scattered, the meter readers are paid an additional flat rate sum per district; this rate varies from 50 ct. to $2 per meter book. A somewhat similar system is in vogue in connection with power and special clients billed monthly, as such customers are limited in number and distributed all over the system. In addition to the regular staff two special meter readers are also employed on a combined fixed salary and piece-work basis to take care of readings by-passed by the regular readers.

C. W. Hunt Retires as Secretary Amer. Soc. C. E.

Charles Warren Hunt for the past 25 years secretary of the American Society of Civil Engineers, has asked to be relieved from active duty. The Board of Direction on Jan. 21 passed resolutions appointing him to the newly created office of Secretary Emeritus, and granted him leave of absence of 6 months, owing to the condition of his health. The resolutions follow:

Whereas, Dr. Charles Warren Hunt, after 25 years of devoted and efficient service as Secretary of the American Society of Civil Engineers, during which he has contributed to its upbuilding and prosperity to a degree which places the society under lasting obligation to him, has indicated his desire to be relieved from active duty, and

Whereas, he possesses an intimate knowledge of the business of the society and an extensive acquaintance with its membership which render his advice and assistance of the greatest value to the society and its Board of Direction, the benefit of which they can ill afford to lose, therefore be it

Resolved, that Dr. Charles Warren Hunt be and is hereby appointed Secretary Emeritus of the American Society of Civil Engineers at a salary of $9,000 for the coming year, and a salary of $6,000 per annum thereafter with such duties as the Board of Direction may assign to him.

Schedules of Engineering Fees

The accompanying abstracts from various proposed schedules of fees for engineering services are of considerable interest. They were compiled by Baar & Cunningham, Engineers, Portland, Ore.

American Institute of Consulting Engineers.—A per diem rate of from $100 per day upwards is proposed. On a percentage basis 1½ to 3 per cent is allowed for preliminary surveys, studies, and reports. For preliminary surveys, etc., with the addition of detailed plans and specifications, 2½ to 5 per cent. For preliminary work, plans and specifications, and general supervision during construction, 4 to 5 per cent, or higher on small jobs. For full professional services, including detailed inspection and management, 6 to 10 per cent or more.

The Pacific Association of Consulting Engineers.—The minimum per diem rate of this association is $50 per day. The percentage fee for preliminary studies, working drawings, specifications and contracts, and general direction of the work is fixed at a 5 per cent minimum. No suggestion is made for full professional services, including inspection.

Civil Engineers' Society of St. Paul.—A percentage fee for a preliminary report with general plan and estimate of cost is fixed at ¾ per cent. For complete plans and specifications, including preliminary report and survey, but exclusive of soundings and borings, the fee is fixed at 3½ per cent for work costing less than $10,000; 3 per cent for work costing less than $25,000; and 2½ per cent for work costing less than $50,000. For consulting superintendence, the charge is 2½ per cent of the cost of the work. This does not include inspection.

Mahoning Valley Ohio Engineers.—The per diem rate is $25 per day. For diem rates are also fixed for the services of assistants of various classes. On a percentage basis for sewer work, including engineering and supervision, 8 per cent is charged for the first $15,000, and 7½ per cent for the second $15,000 of the estimate. For paving work, 7 per cent is charged for the first $15,000, and 6½ per cent for the second $15,000. The client is to pay for one inspector on percentage work. It would appear that the intention is that these fees are to cover simply general supervision, but not inspection.

Iowa Engineering Society.—The per diem rate is fixed at $15 to $25 per day. The percentage rate for preliminary services is 1½ per cent for these services and in addition the preparation of drawings, specification and contracts, and letting the contract, 2½ per cent. For all preliminary services, and also consulting supervision of the work, 5 per cent. For full responsibility, including inspection and all engineering services, 6 per cent.

Edmund T. Perkins' Paper Before the Illinois Society of Engineers.—This is an elaborate schedule, and proposes a sliding scale for charges on work of varying magnitude. The fee for full professional services, including superintendence, varies from 12½ per cent for jobs of less than $5,000, to 4.2 per cent for jobs of over $500,000. These percentages do not, however, include inspection. The statement is made that, "A schedule rate for superintendence applies when the engineer who has designed and planned the work, or his assistant, superintends construction. All other employes than such assistant or assistants are to be paid by the owner."

Connecticut Society of Civil Engineers.—The percentage fee for preliminary conferences, estimates, and reports is from 1 to 1½ per cent. For these services and plans and specifications, 2½ to 5 per cent. For all preliminary services and general supervision of construction, from 4 to 8 per cent. For full professional services, including inspection, from 6 to 12 per cent.

POWER AND PUMPING SECTION

This section of the Waterworks and Hydraulic Monthly issue of Engineering and Contracting is devoted to the selection of power and pumping equipment and the economic management of its operation.

Electrically Operated Pumping Plants in Indiana

According to available records there are 206 public waterworks systems in the state of Indiana. Seventy-six of these, more than one-third, are operated partially or wholly by electricity. During the past winter and spring, twenty-seven of these plants were visited by members of the Engineering Experiment Station staff of Purdue University with a view to ascertaining the present status of electrical operation of such plants. The results of this investigation were given in a paper presented at the annual meeting of the Indiana Engineering Society in Indianapolis, Jan. 23-24, 1920, by G. C. Blalock, Instructor in Electrical Engineering, Purdue University. Some useful and interesting data may be obtained from this paper, as the following extracts will show:

Operating Conditions at Pumping Plants.—The plants visited supply water to communities ranging in population from 5000 to 25,000 and were found to be operating under a variety of conditions.

Fifteen plants used some form of elevated storage—tank, standpipe or reservoir; six were provided with compression tanks, the pressure being automatically controlled by pressure gage relays, while the remaining six had no provision for storage but maintained direct pressure by continuous operation of the pumps. This probably represents in a general way the distribution as to types of plants over the state as a whole.

About 20 per cent of the plants visited made use of deep well pumps—air lift or displacement. The remainder used surface pumps; though in many cases the pumps were placed in pits from 4 to 15 ft. below ground level in order to reduce the suction lift.

The most commonly encountered source of water supply was the drilled well, 6 to 10 in. in diameter, and from 100 to 300 ft. in depth. In a few cases the supply came from streams or spring-fed reservoirs, but these were rather exceptional. In most localities the water stands from 10 to 20 ft. below ground level, but in a few places the water flows to the pump under sufficient head to eliminate entirely the necessity for priming.

Centrifugal pumps and triplex displacement pumps were encountered in about equal numbers and the plant which contained neither of these types was exceptional. One rotary pump was observed, handling the second stage of a two stage system; and the city of Lafayette has three direct connected motor driven propeller pumps forming the first stage of a two stage system, the second being handled by steam pumps. These, however, are held for emergency use, the first stage pumping being normally done by air lift. Also in one case the first stage was handled by motor driven deep well pumps and the second stage by steam pumps. In 75 per cent of the plants inspected the single stage system was used.

Alternating current energy was utilized in practically all cases. Various types of motors were found to be in use, the choice depending chiefly upon type of pump to be driven. In most cases the available energy supply is 60 cycle, 3 phase current, and the choice lies between the squirrel cage and the wound rotor types of induction motor, the former being used for driving centrifugal pumps, where the starting load is light, and the latter for driving displacement pumps where the starting load is relatively heavy. Exceptions were noted, however, to this general rule, and in one case synchronous motors were found giving very satisfactory service. Single phase, 25 cycle motors were encountered in one plant, the energy being obtained from an interurban railway transmission line which passed through the town.

The pressures in use for domestic service were found to range from 25 to 90 lb. per square inch, the average being about 40 lb. In many cases provision is made for raising this pressure for fire-fighting purposes to 90 or 100 lb. by cutting off the storage and bringing a special high pressure unit into service. It is not uncommon to find steam pumps used for securing the extra pressure needed for fire service, though the motor-driven fire service pump is popular in localities where auxiliary steam equipment would be expensive to provide and maintain. There appears to be a growing sentiment in favor of securing the extra pressure by using a portable pump at the location of the fire, rather than by boosting the pressure over the whole system, thereby making both mains and plumbing liable to damage or even complete failure at a time when such failure would be most serious. This method also eliminates the extra demand for water at service connections during the high pressure periods when the greatest possible supply should be available for fighting fire.

The average pump capacity provided for domestic service appears to be about 200 gal. per minute, per 1,000 population, but this figure is not of very great value since the capacity required depends very largely upon local conditions and may vary widely for towns of the same population. Also the system used has considerable influence upon the pump rating. The pumping units designed for special fire service average about 250 gal. per minute capacity per 1,000 population. These units also provide reserve capacity for abnormal demands other than for fire service.

Town officials and operating men expressed themselves almost unanimously as well pleased with the results obtained through use of electrically-operated equipment. Appreciation of the greater convenience and decreased operating expenses was especially marked in places where the pumps were previously steam driven. One of the most frequent sources of trouble appeared to be due to freezing in severe winter weather. Bursting of pump cylinders was reported in numerous instances. In some cases these breaks had been repaired by welding, in others the cylinder had to be replaced. Troubles from this source can be charged only to neglect in providing some means for keeping the temperature sufficiently high to prevent freezing.

Metering at Pump Discharge.—The practice of selling water by meter appears to be rapidly superseding the old flat rate system. Of more than 13,000 service connections reported nearly one-third were metered. Four systems were entirely metered while only two had no meters at all. Many towns are changing over to the meter system as rapidly as circumstances permit and expect to have all connections metered within a year or two.

Only six of the towns visited had provision for metering the pump discharge, despite the obvious advantage of having this means of checking the performance of the pump and motor. With a watthour meter on the input side of the unit, and water meter and pressure gauge on the output side the duty and overall efficiency may readily be determined at any time and any marked drop detected and unaccounted for. A centrifugal pump needs particularly to have its performance checked to avoid the marked drop in efficiency which occurs when the impeller is not properly designed for the conditions under which it is working. The substitution of an impeller of slightly different design may effect a saving which will pay for both meter and impeller within a comparatively short time.

Pumping Plant Operation Records and Costs.—It was found rather difficult to obtain accurate records of plant operation and costs, particularly in the smaller towns. Combined power and pumping plants frequently do not provide separate meters for measuring the energy supplied to the pump motors nor divide the operating costs equitably between the power and pumping departments of the plant. Data for calculating energy consumption per 1,000 gal. of water pumped were obtained for 14 towns. In kilowatt-hours per 1,000 gal. this energy consumption ranged from a minimum of 0.20 to a maximum of 3.28, giving an average value for the 14 towns of 1.31.

Since there is considerable variation in the total head against which these pumps are working a better measure of performance may be obtained by reducing the figure given for each plant to a basis of 100 ft. total head. This gives values ranging from 0.125 to 1.96 with an average of 0.90 kw.hr. per 1,000 gal. per 100 ft. head.

The operating cost per 1,000 gal. was found to range between 0.88 and 16.83 ct., with an average value of 4.97 ct. Reduced to a basis of 100 ft. head this average becomes 3.74 ct. per 1,000 gal. per 100 ft. head.

Tests of Pumping Plants.—Two plants equipped with meters for measuring the pump discharge were selected, and tests were run, with two objects in view; first, to determine the duty and overall efficiency of the pumping unit, thus obtaining a basis for figuring energy costs per unit discharge; and second, to determine the nature of the power demand and thereby establish the degree of desirability of pumping loads from the central station point of view. The test in each case extended over a period of 24 hours, and in addition to kilowatt-hour and water meters a graphic recording wattmeter was used for measuring and recording the power demand.

The unit tested in the first plant consisted of 2½ in. single stage, 175 gal. per minute, centrifugal pump, driven by a 15 h.p. squirrel cage type induction motor; pumping continuously against a direct pressure of the mains. A total pumpage of 11,900 cu. ft. was observed—an average rate of 61.8 gal. per minute—against a pressure of 40 lb. per square inch with input of 9.38 h.p., giving an overall efficiency of 16.7 per cent. Estimates based on pipe friction tables give about 10 ft. loss of head in elbows, valves, meter, etc., between the pump intake and the point at which the pressure gauge was attached to the main. Including this loss of head raises the efficiency about 2 per cent. This still gives a very low overall efficiency, but it should be noted that the pump is discharging but little more than one-third its rated capacity; this resulting in the motor running at considerably less than its normal rating. Neither pump nor motor can therefore be expected to show very good efficiency. It is evident that this unit is not operating under the conditions for which it was designed, resulting in high energy consumption per unit output.

The unit tested in the second plant consisted of a 4 in., 2 stage, 380 gal. per minute, centrifugal pump, driven by a 25 h.p. squirrel cage type, induction motor; pumping to mains, with standpipe storage, the frequency and duration of pumping periods being regulated by a pressure gauge relay and an automatic motor starter.

Three runs of approximately two hours each, at an average pressure of 55 lb. per square inch, gave a pumping rate of 350 gal. per minute, with an input of 32.35 h.p., showing an overall efficiency of 38 per cent. Estimated loss in head due to friction amounts, in this case, to about 35 ft.; an inclusion of this loss as part of the total head raises the efficiency about 10 per cent. The overall efficiency in this case checks closely with manufacturers' estimates for this size and type of unit; and the unit is evidently well adapted to its work.

Conclusions.—The conclusions arrived at as a result of investigation and study of the present status of electricity in the pumping plants of the state may be summed up as follows:

Where local conditions have been carefully considered, and the type and capacity of pump and motor which best suits those conditions intelligently selected, electrically driven pumps have proven highly satisfactory; they have been found to be easily handled, convenient, reliable and economical.

While the motor itself is very unlikely to give trouble, and transmission lines have proven quite reliable, yet it appears advisable to provide some auxiliary source of power. The automobile type gasoline engine appears particularly well suited to this purpose.

The energy consumption in properly designed plants may be expected to vary from 0.2 to 2.0 k.w.-hours per 1,000 gal. per 100 ft. head, with 1.0 as a fair average.

The operating expenses for an electrically operated plant are low; considerably below those for a steam plant and appreciably below those for an internal combustion engine plant.

The pumping plant load is a desirable one from the central power station point of view.

Suggestions for Fuel Saving in Steam Generating Stations

During the last few years the importance of coal saving has been emphasized more than ever before, and the results attained in this direction have been substantial and well worth the efforts that have been made. There is room, however, for still further improvement, and it is essential that all methods productive of good results in the past should be continued, and that other methods that tend in the same direction should be adopted, if they can be discovered. Useful suggestions along this line are given in the December Travelers Standard, a publication of the engineering and inspection division of the Travelers Insurance Co., and the Travelers Indemnity Co., from which the matter following is abstracted.

Coal Conservation in the Boiler Room.—Coal, of course, is by far the commonest fuel in use for the generation of power, and the largest saving of it can be effected at the point of combustion—namely, in the boiler-room.

The inefficiency of steam power plant equipment, as employed under average conditions, is well known. It varies, however, in accordance with the amount of attention that is given to the design, installation, and operation of the apparatus. In connection with the situation in general, Technical Paper No. 206 of the United States Bureau of Mines contains an interesting and suggestive statement, from which we extract the following passages: "In the average steam plant 57 per cent of the heat in the coal burned under the boilers is utilized in making steam and 43 per cent is lost—that is, out of every 100 tons of coal fired under the boiler, 57 tons are actually utilized in making steam, and 43 tons are not used, from various causes. Some of the large plants get results considerably better than this, but many of the small plants get poorer results. Records of the best performances show that about 80 per cent of the coal burned was actually utilized in making steam, and although such high results cannot be obtained with the existing apparatus or equipment in some plants, a requirement of 65 to 70 per cent is justifiable." This, of course, relates to the efficiency of the boiler alone. If we adopt the provisional data suggested for purposes of illustration in Technical Paper No. 217, assuming the combined efficiency of the boiler and furnace to be 60 per cent., and that the steam operates a direct-connected reciprocating engine, we are led to the conclusion that in the illustrative case only 4.29 per cent of the heat of the coal consumed is delivered to the engine shaft or flywheel in the form of mechanical energy; and on account of friction, electrical resistance, imperfect conversion in the generators, and other losses, this is reduced to 3.99 per cent in electrical energy delivered at the switchboard. A result of this startling character should interest every power-plant owner, at once, and lead him to adopt all possible means that give promise of better returns. Quite a large part of this loss is due, it is true, to the theoretical limitation that is imposed, by the second law of thermodynamics, upon the efficiency of conversion of heat energy into mechanical energy; but in addition to this necessary and unavoidable loss, there are many other losses that we can easily prevent, thereby bringing the final figure up to a far more reasonable value.

Needlessly High Temperature of Flue Gases.—One of the most prominent causes of avoidable loss is the needlessly high temperature of the gases that pass out through the stack. These gases must necessarily be as hot as the contents of the boiler, unless they are cooled by means of an economizer, superheater, or other heat-saving device. Moreover, they must in any event be hot enough to give a good draft in the chimney, or else they must be handled by a mechanical draft apparatus, which itself absorbs power and calls for a certain consumption of coal. In many plants, however, the temperature of the flue gases is needlessly high, and the excess of heat that passes away in them, over and above that which is required for the maintenance of a good draft, is entirely wasted. High flue-gas temperature may be due to poor boiler design, or to forcing the boilers beyond a reasonable limit of duty, or to the accumulation of soot or scale upon the heating surfaces, so that the heat in the furnace gases cannot be efficiently absorbed by the boiler. The fact that heat is being wasted on account of needlessly high temperatures in the flues often escapes attention for the simple reason that the high temperature is not at all obvious. Yet it may be detected easily by means of a thermometer.

Too great a dependence should not be placed, however, upon the results obtained by merely reading a thermometer that is exposed to the flue, because large quantities of heat may be wasted in the flue gases without any really commensurate increase in temperature. Loss of this kind is due to leakage of cold air through the setting walls or around front-connection doors, or to the admission of more air to the furnace than is required for proper combustion. Large amounts of excess air will pass up through the fuel bed if the fires are allowed to burn unevenly, so that "holes" are formed over the grates. Excessive air entering the furnace or the gas passages in any such way may absorb a significant and important fraction of the heat derived from the fuel, and although a considerable part of the heat thus absorbed is lost, it is plain that the thermometer in the flue does not necessarily show an extravagantly high temperature. Many boiler owners and boiler attendants fail to realize that for every ton of coal that is consumed, 14 tons of air must pass through the furnace. If the air supply is 50 per cent greater than is needed for good combustion, every ton of coal therefore has to heat 7 tons of air from the prevailing outdoor temperature up to the temperature in the flue, without any useful result being attained, and this means a large waste.

Effect of Air Supply on Combustion.—Important as it is, however, to prevent the admission of excessive air, it is still more important to avoid cutting down the supply below the quantity that is required for proper combustion. Deficiency of air, in other words, is even more wasteful than excess. A pound of carbon, for example, may take up 1.35 lb. of oxygen and become converted into carbon monoxide, or it may take up 2.70 lb. of oxygen and become converted into carbon dioxide. The amount of heat given out when the carbon absorbs the second 1.35 lb. is much greater than the amount given out when the first 1.35 lb. are absorbed. Hence it is extremely important to oxidize the carbon as completely as possible, so as to avoid letting any monoxide escape, unburned, up the flue. We cannot discuss firing methods in detail in this article, but it is essential to give careful attention to them, if good results are desired. To avoid costly losses (especially in hand-fired plants) it is exceedingly important to employ competent, skillful firemen, and to see that the firing is properly done. An unskilled man can easily waste far more than his full pay. He is dear at any price, and to employ him (provided a good man can be had) is emphatically "penny wise and pound foolish."

Design and Proportions of the Boiler Furnace.—These have an important bearing on fuel economy. For example, combustion will necessarily be imperfect unless the gases in the furnace are maintained at a high temperature until the oxidation is complete. It is still common to provide boilers with furnaces of a conventional type that has been used for many years, without any serious attempt at improvement. This does not show good judgment. It is far better to consult an expert who will study the conditions under which the boilers are to be operated, and determine what form of furnace is best, basing his decision upon sound experience and well-tested theory, rather than upon mere tradition.

A good draft is one of the most essential features of satisfactory and economical boiler operation. It is better to have it too powerful than too weak, because it can be checked far more easily than it can be fortified. If it is feeble, a serious situation is presented which can usually be remedied only by a considerable outlay of time and money. Moreover, a powerful draft is exceedingly valuable whenever it is necessary to force the boilers beyond their normal capacity in order to meet some emergency, or when it becomes desirable to use low-grade fuels or waste products under the boilers.

In many manufacturing plants there is a constant loss due to failure to utilize combustible waste products as fuel. It is sometimes necessary to mix the waste product with coal in order to burn it properly, but in other cases this is not essential, provided a suitable special furnace is installed. Waste of the most unpromising character can often be burned satisfactorily when the right way to handle it is known, and what might otherwise be a nuisance and a source of expense may be thereby turned into profit. Waste gases from special-process furnaces are often employed to generate steam in boilers, and wet sawdust, tanbark, bagasse, and many other apparently useless organic materials can be utilized to good advantage.

Unburned Coal in Ash.—The fireman, when using coal for fuel, may think that the ash that he is throwing away is practically free from unburned coal. It is easy for him to be mistaken, however, and it is advisable to examine the ashes critically and carefully, from time to time, to find out what the real facts are. If too much coal is found, the firing methods should be considered, to see how they can be improved, and the grates should be inspected frequently, to see that they are in good condition. Grates that are not adapted to the coal may easily cause heavy waste.

Keep all boiler surfaces free from soot, ashes, dust, scale, and sediment. Even a thin coating of any one of these nonconducting substances reduces the efficiency of the boilers and causes a corresponding increase in the quantity of fuel required. Flue brushes, tube cleaners, and scale-removing tools should be used as often as conditions require, and ash-pits and combustion chambers should be kept free from ashes.

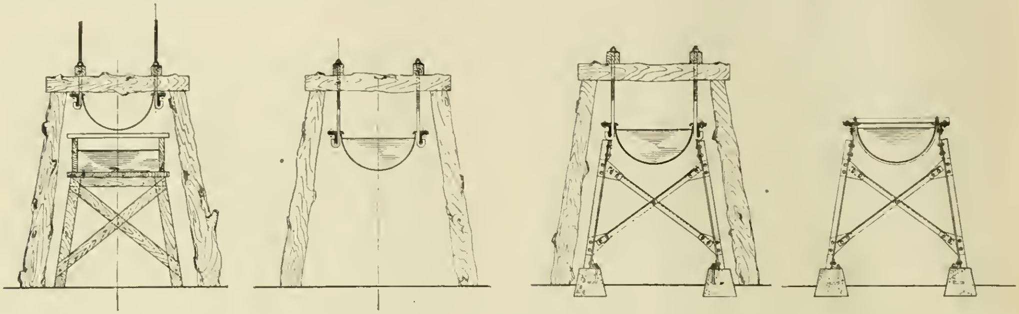
Steam leaks about the boilers, engines, pumps, valves, piping and fittings cause an unnecessary consumption of fuel, and the loss from such leakage is usually much greater than the owner of the boiler realizes. Be particular to see that all pipe joints are well made up. Keep all valves and fittings tight, and maintain all gaskets and packings in good condition. Give special attention to the blow-off valves to see that they are kept tightly closed, and to all traps that discharge directly into sewers, because even a slight leakage here means a daily waste of many gallons of hot water.

Save all water of condensation from radiators, pipe coils, and other heating devices, and from steam-using apparatus of every other kind; and use exhaust steam rather than live steam for heating water for process work, for room-heating, and for other purposes so far as possible. Vent all radiators and heating pipes in order to remove the air and thus secure the highest possible efficiency from them. The use of self-closing hot-water faucets in wash-rooms will eliminate a considerable amount of heat waste. Cover all steam pipes and hot-water pipes with approved heat-insulating material.

Municipal Ice Plant of Omaha, Neb., Shows Profit.—A public ice plant operated by the Metropolitan Water District of Omaha, Neb., was completed in January, 1919, at a cost of about $271,000. Operation of the plant, however, with one tank was begun on Aug. 25, 1918, and 6,850 tons of ice were produced before the end of the year. The method of distribution adopted was by delivery, at wholesale, and, at retail, through nine ice stores (including the ice plant), located in various portions of the city. The success of the stores, according to The Public Service Bulletin of the district, was instantaneous. The ice was sold at the rate of 5 ct. per 15 lb., or any multiple thereof, or 33.5 ct. per hundred. After charging against earnings, depreciation, interest at 4.5 per cent and a sinking fund of 1.5 per cent, the surplus up to Jan. 1st, 1919, amounted to $3,036. Beginning late in January, 1919, the plant produced 14,752 tons of ice up to July 1, 1919, and still had in storage 6,818 tons. The ice stores were opened in May, their number having been increased to 17, and met with the same favor as before. The ice making equipment was installed by the Arctic Ice Machine Company, of Canton, O., is electric driven, of the drop pipe, raw water type. Closed condensers are used and the cooling water is supplied from a large water main under pressure and returned thereto at an increased temperature of not to exceed 4° F. While the long storage has a capacity of 8,500 tons, it is regrettable that it is not larger.

Method of Replacing Old Wooden Flume with Metal Structure

Old wooden flumes on an irrigation ditch in Calveras County, California, were replaced last summer with metal flumes without seriously interrupting the flow of water. The new installation consists of Armco flumes of the Lennon type supported on steel substructure. The girders are 3 in. by 2 in. angle iron, and the supports 3 in. by 2 in. angle iron spaced 21½ ft. apart. Braces extend from these supports, meeting the girders at a distance of 7 ft. 2 in. from the supports dividing the spacing into three equal parts, each 7 ft. 2 in. in length.



Progressive Steps in Flume Installation.

Sketches from Left to Right Show: Scaffolding built over old flume, steel girders hung to scaffolding by hook bolts. Old flume removed, girders lowered to grade boxes put in place, water running through them. Steel legs hung to girders and concrete pillars up to meet them. Steel flume finished and scaffolding removed.

The season being very dry it was necessary to interrupt the flow through the ditch as little as possible while the work on the flumes was in progress. To attain this result the following method was employed:

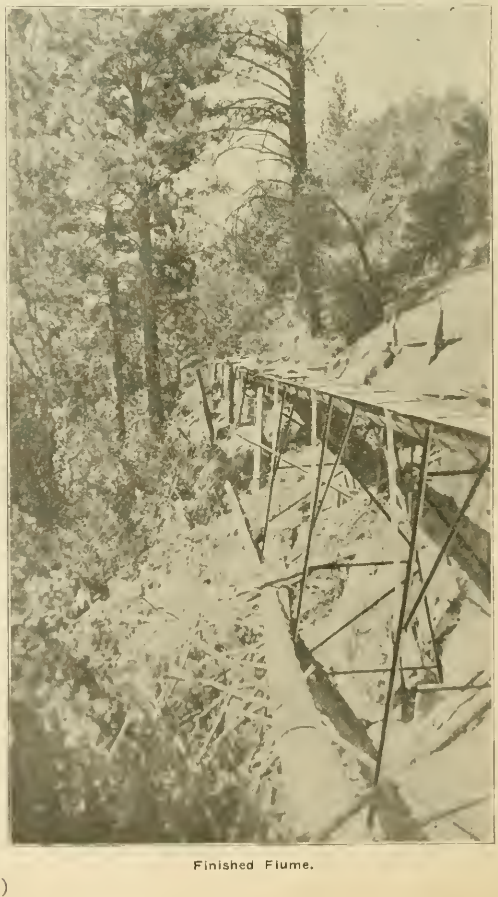
The scaffolding required to handle the 3 in. by 2 in. girders was used as a temporary support for the flume. The scaffolding was made of pine poles cut on the ground. The old flume was kept in place while the scaffolding was being built. When the scaffolding was finished the girders were suspended under it, over the old flume, by means of hook bolts, the ends of which had long threads. The girders were coupled together, and it was only as this work was finished and the girders were ready to be lowered to grade that the old flume was taken out of the way.

This was done early in the morning. One girder was lowered to grade by loosening the nuts of the hook bolts one after the other. As soon as this was done the other girder was lowered to place. In the same way the flume boxes were put together, this work proceeding so rapidly that by the end of the day a flume 200 ft. in length had water running through it. The flow of water had been interrupted for only 8 hours. While the new flume was in use and water running through it the steel supports and braces were bolted to the flume girder.

Concrete pillars were built to meet the supports. When the concrete had set the hook bolts and scaffold were removed.

Some 1,200 ft. of wooden flumes were thus replaced, with

Donkey Train Conveying Sand for Concrete Pillars. This Is Typical View Showing Roughness of Country.



Finished Flume.

The Old Wooden Structure Was Kept in Commission While the Metal Flume Was Erected.

a total interruption of water flow not exceeding 36 hours. The flumes complete cost in the neighborhood of $5 per foot. The work was done on the Ide and Terwilliger ditch of D. Fricot.

Air Agitation Promotes Alum Coagulation

The use of air to agitate the coagulant and raw water was found to remedy the disappearance of alum floc in the filtration plant at Bridgeton, N. J. Since the completion of the plant in 1913, difficulty in operation at certain season of the year has occurred, due to the disappearance of the alum floc and the consequent decrease in the quality of the filtered water. Several remedies were tried without avail, according to Charles H. Capen, Jr., Assistant Sanitary Engineer, State Department of Health of New Jersey, in "Public Health News," published by the same department.

It is stated that the trouble always occurred at times of very low alkalinity in the raw water when it was necessary to exercise unusual precautions in the addition of chemicals. Practically no mixing of the chemicals and raw water takes place, as the plant was built.

Laboratory experiments shows that a violent mixing of coagulant and raw water produced the desired floc. More thorough mixing was obviously required.

After considering various methods that could be used to produce the desired effect, including baffling and mechanical agitation, it was decided to use compressed air applied to the raw water near the entrance to the coagulation basin. An air compressor was connected and a 2-in. pipe run to a horizontal perforated pipe placed across the basin several feet below the surface near the entrance and perpendicular to the direction of flow. The violent agitation by the air immediately produced a heavy floc.

Since the installation of the compressor, the plant has passed through several critical periods with no difficulty in operation.

Reclaiming the Zuyder Zee, Holland.—It is expected work will be started this year on the reclamation of the Zuyder Zee. The work will be done by the state and will involve an expenditure of about $125,000,000. It will reclaim 827 square miles of land.

Labor Cost of Constructing Intercepting Sewer in Essex County, Ontario

In October, 1918, the Essex Border Utilities Commission, representing seven municipalities on the Detroit River in Essex County, Ontario, awarded the contract for the construction of an intercepting sewer, which will form part of the sewerage disposal scheme of the commission. The contract included:

942 lin. ft. 15-in. vitrified pipe sewer.
1.469 lin. ft. 18-in. vitrified pipe sewer.
1,555 lin. ft. 20-in. vitrified pipe sewer.
2,585 lin. ft. 24-in. vitrified pipe sewer.
2,037 lin. ft. 30-in. segment block sewer.
3,709 lin. ft. 33-in. segment block sewer.
254 lin. ft. 20-in. reinforced concrete force manholes.
48 brick manholes with concrete base and cast iron frame and cover.

Labor costs of constructing this sewer are given by Mr. Charles W. Tarr, of Morris Knowles, Ltd., consulting engineers, in The Canadian Engineer, to which we are indebted for the matter that follows:

About 81 per cent of the sewer was laid in tunnel and shaft excavation, the material being largely a blue knifing clay, to which that method was especially adaptable. In order to delay traffic as little as possible, the interceptor was placed under the sidewalk or parking space wherever practicable. About one mile was placed directly under the sidewalk, which was disturbed only where shafts were located.

The force main crossing under the main line of the Grand Trunk, a double-track railway with sidings, was laid in open cut, the two main-line tracks being supported on stringers over caps on round piles. The other two crossings under spur tracks were made without special work, the usual concrete envelope 4 in. thick, as specified by the Ontario Railway Board, being put around the pipe at all railroad crossings. Three crossings under the trolley track caused no inconvenience to the tunnelers.

A section of the work 1,843 ft. long, with depths from 11 to 18 ft., was excavated by means of a trenching machine. Back filling the open cut trench was done with a team and scraper, using a long cable to span the trench.

At the start of the work, it was expected that some difficulty would be encountered in securing labor, but as the work progressed, sufficient men were available and the rates of pay were reduced, with the greater number employed at the lower rates.

Labor Force and Rates of Pay.—The following table gives a representative list of workmen and their average rates:

	Rates per hour.	Maximum number employed per day.
Foreman	$8-$6 per day	3
Tunnelers	90-70 ct.	*5
Block-layers	90-70 ct.	4
Brick-layers	90-70 ct.	4
Laborers	65-45 ct.	66
Teams	80-70 ct.	9
Horse and man	60 ct.	4
Wagons only	25-40 ct per day	10

*Nearly all work done on lineal foot basis.

A large amount of the work was done on a production basis, which made for shorter hours and greater progress. The tunneler and shaft-digger, also the bricklayer on the manholes, worked on this basis at the following rates:

	Rate per lineal ft.	Maximum daily production.
Tunneling	$1.35-$0.80	113 ft.
Shaft sinking	3.50- 2.20	40 vert. ft.
Manholes	1.25 per vert. ft.	122 ft.

The maximum force was employed during the two weeks ending January 16, 1919, it being over three times the amount employed in November, 1918, when work was well under way, and four times that at the end of May, 1919, when the larger part of the work had been completed.

Shaft and Tunnel Excavation.—Shaft sinking was done by hand, using picks, spades and grubs, the material being shoveled from platforms placed at vertical intervals of approximately 7 ft. Generally the major portion of the material was piled alongside the shaft for backfilling. Two men worked together in the bottom, being paid for the number of vertical feet excavated. The platform and top men worked by the hour.

The shafts, spaced about 75 ft. apart, averaged 5 by 8 ft. in area, with depths from 11 ft to 21 ft. Of the shaft excavation 80 per cent was in hard, yellow clay, requiring sharp picks to loosen it. All shafts were braced, using rangers 6 in. by 8 in., with lagging 2 in. by 8 in., spaced 8 in. apart. Where the depth of the sewer exceeded 10 ft., the 5 by 8 ft. shaft was used; but in shallow excavation, an elongated, narrow shaft about 15 ft. in length was used, leaving about 35 ft. between shafts to be tunnelled.

Tunnelling was done by men experienced in that type of work; clothed in oil-skins and using short spades, they passed the excavated material back to a mucker who in turn loaded it at the bottom of the shaft into a bucket holding about ¼ cu. yd., from which point it was drawn to the top by a horse-operated windlass especially made for this work. Two shafts with four headings were worked simultaneously and required the following force and equipment: 4 tunnelers, 4 to 8 muckers, 2 top men, 1 horse and driver and 8 mud buckets.

The hoist used was a portable frame outfit, occupying a space about 6 by 10 ft., with a platform 5 ft. above ground level, on which a short pair of rails was fastened and a flat car operated. Two hoists were generally operated together, one of which was equipped with a vertical drum and horizontal lever, to which a horse was hitched. Cables from this drum ran over sheaves and down each shaft, being so wound that as one was lowered the other was raised. The horse was equipped with a swivel yoke and could be readily turned to travel in either direction around the center of the drum.

A mud bucket being filled at the bottom of the shaft, it was raised as an empty one was lowered in the adjoining shaft. The top man ran his transfer car under the full bucket and attached an empty bucket to the cable. The full bucket on the transfer car was pushed to the edge of the platform and emptied into a wagon. One pair of horses handled two wagons, leaving an empty one at the hoist while removing the loaded one to the spoil dump.

Pipe Laying and Backfilling.—Block-laying and pipe-laying followed the completion of excavation between shafts, the heavier pipe being lowered by means of the usual type of A-frame windlass, having a light wagon wheel on the end of the shaft and a friction brake. Backfill in the tunnel was done by the block-layer or pipe-layer with blue clay, packing it in by hand as each joint of pipe was laid. Backfill in the shafts was partially made by dumping wagon loads of material from excavation ahead through holes in platforms over the shaft openings.

The feature of the work was that it was started in October and pushed to completion through the winter season, thus releasing the labor and equipment in June and July to take up the summer contracts.

The elapsed time was 267 days, or 9 months. Subtracting 38 Sundays, the total number of working days were 229. The workings days lost totalled 10¼, due to armistice 2, Christmas 1 and rain 7¼. The total days worked were 218¾. The length of work was 12,551 ft., or 57 ft. per day worked.

Excavation Costs.—The largest cost item of the work was excavation, as the interceptor was laid at a depth of 12 ft. to 22 ft., with an average depth of about 18 ft. The following table gives itemized labor costs for shaft and tunnel excavation. This is actual cost, without profit or workmen's compensation, and the considerable variation in unit prices is due to particular local conditions encountered and to the necessity of varying the rates of pay to meet the labor conditions encountered.

UNIT COSTS AND DATA ON SHAFT EXCAVATION.

	Segment block.			Vitrified sewer pipe.		
Diam. sewer in inches	33	33	30	24	20	18
Number of shafts opened	52	13	31	39	19	9
Average depth in ft.	10-18	18-22	14-19	15-21	19-20	12-20
Total cu. yd. shaft excav.	966	406	835	805	394	152
Ave. cu. yd. per shaft	18.5	31.3	27.0	20.6	20.7	17.0
Total cost shaft excav.	$2,787	$2,125	$4,809	$1,913	$1,254	$505
Ave. cost per shaft	$54	$163	$155	$49	$66	$56
Ave. cost per cu. yd.	$2.90	$5.20	$5.75	$2.38	$3.18	$3.30

UNIT COSTS AND DATA ON TUNNEL EXCAVATION.

Length of tunnel in ft.	2,295	728	1,744	2,289	1,427	502
Average size in in.	43x54	43x54	40x48	34x48	29x40	29x40
Cu. yd. per ft.	.50	.50	.40	.28	.25	.25
Total cu. yd	1,148	364	698	641	357	126
Total cost tunnel excav.	$6,591	$1,626	$5,151	$5,088	$2,366	$1,039
Aver. cost per lin. ft.	$2.87	$2.23	$2.95	$2.22	$1.89	$2.07
Ave. cost per cu. yd.	$5.74	$4.47	$7.48	$7.94	$8.30	$8.24

Pipe Laying Costs.—The following table gives unit costs for laying pipe and backfilling shafts and open trench. These also are actual costs without profit or workmen's compensation. Wherever pipe was laid in tunnel, the cost includes backfilling, because as each length of pipe was laid, the opening above it, approximately 12 in., was immediately filled and tamped with blue clay.

The unit costs for backfilling are for shafts and open trench only, as the backfilling in tunnel was included in pipe-laying, as explained above.

PIPE LAYING COSTS.

Diam. sewer in in.	33	33	30	24	20	18	15	*20
Length of pipe in ft.	2,799	822	1,966	2,540	1,535	1,446	928	252
Total cost pipe laying	$2,710	$933	$2,592	$1,699	$864	†$482	‡$131	$241
Cost per ft.	$0.97	$1.14	$1.32	$0.67	$0.56	$0.33	$0.14	$0.96

BACKFILLING COSTS.

Diam. sewer in in.	33	33	30	24	20	18	15	*20
Total cu yd.	708	334	725	762	355	¶1,113	‖979	113
Total cost back-filling	$671	$120	$173	$331	$225	$570	$733	$109
Cost per cu. yd.	$0.95	$0.36	$0.24	$0.43	$0.63	$0.51	$0.75	$0.96

*Force main. †61% in open trench. ‡100% in open trench. ¶88% in open trench. ‖100% in open trench.

This work was done on the basis of actual cost, plus a fixed fee on a sliding scale. The fixed fee for completing the work was $12,000, being about 10 per cent of the estimated cost of the work. This fee was increased by 25 per cent of any saving the contractor made on his estimated cost, and decreased by 10 per cent of any amount he exceeded his estimate. The total labor cost, exclusive of workmen's compensation, which runs about 2½ per cent of the payroll, and also exclusive of profit, was as follows:

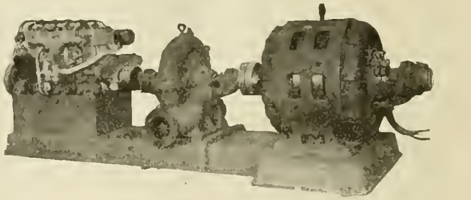
		Cu. yd.	Per cent of labor cost.
Shaft excavation	$13,293	$3.77	21.3
Tunnel excavation	22,461	6.75	35.8
Backfilling	2,932	.58	4.6
Machine and open-cut excavation	2,581	.....	4.1
Pipe-laying	9,652	.....	15.4
Manholes	2,780	*58.00	4.4
Paving	1,187	.....	1.9
Removing supplies and cleaning up	7,088	.....	11.2
Pumping, miscellaneous repairs, etc.	780	.....	1.3
	$62,854		100.0

*Each.

The interceptor was constructed by Merlo, Merlo & Ray, Ltd., contractors, Walkerville, Ont. The interceptor was designed and the construction work supervised by the firm of Morris Knowles, Ltd., whose president, Mr. Knowles, is chief engineer of the Essex Border Utilities Commission.

An Electric-Motor-and-Gasoline-Engine Driven Fire Pump

It is always desirable to have two independent sources of power for a fire pump so as to lessen the chances of its being put out of commission when a fire occurs. In some states, a double drive is required by the Underwriters' regulations.



Double Drive Fire Pump.

The usual form of drive is a steam engine and electric motor, though where there are two separate sources of current two electric motors are frequently used. Sometimes neither steam nor a second source of current is available, and in that case a pump such as that shown in the illustration can be used. This pump is of 1,500 gal. per minute capacity and is driven by a Westinghouse 150 hp., alternating-current motor and a 140 hp. gasoline engine. It is built by the Lea-Courtney Co., Newark, N. J.

$52,000,000 Public Work Program for Baltimore.—The new Annex Advisory Commission of Baltimore, in a report submitted last week outlined an improvement program amounting to $52,261,000. Of this sum $22,000,000 is for waterworks improvements and $16,000,000 for sewerage.

The New $1,250,000 Milton Reservoir of Youngstown, O.

The city of Youngstown, O., is now receiving the benefits from supplying an adequate water supply for its industries. A few years ago many of the steel plants centering around Youngstown were making no enlargements to their existing plants and were even considering moving to locations affording a better water supply. Fortunately, the city acted and constructed a dam forming a new reservoir. The result is that new industries and additions to existing plants have been rapidly increasing. One plant alone has added 5,000 men. In a paper read at the recent annual meeting of the Ohio Engineering Society, Mr. F. M. Lillie, City Engineer of Youngstown described the main features of the improvement. The matter following is abstracted from his paper:

Several sites for storage dams existed in the Mahoning River and its tributaries above Youngstown, but, all things considered, it seemed most desirable to build a first dam on a site in Milton Township in Mahoning county. The area of the water shed above this point is about 290 square miles. This site is about 20 miles straight west of Youngstown but it is nearly twice that distance by the river. It is about 14 miles above Warren by stream and 4½ miles above the village of Newton Falls, Trumbull county. About 3,300 acres of land were acquired in this basin, some of which was later sold.

Across the valley at this site the city built the structure known as Milton Dam. The dam has a total length of 2,846 ft. The spillway is of concrete, 638 ft. long, and is built into concrete abutments at each end. The west abutment is prolonged to give room for four 60 in. pipes through this abutment. On the top, which is 20 ft. wide by 41 ft. long, is mounted the apparatus for operating the four, 60-in. gates. The entire length of the spillway and abutments is 710 ft.

The valley at the dam site is underlaid with rock, covered with from 20 to 30 ft. of glacial gravel, silt and clay. The rock was deepest at the east abutment, at which point it was about 64 ft. below the top of the finished structure. The crest of spillway is at elev. 950 above sea level and the top of abutments 10 ft. above. The surface of the stream in the river channel was at elev. 904 when the work was begun. The rock was close to 900. At the east abutment it was 10 ft. lower. The dam on its back surface has a batter of 1 in 10, on the face it sloped 7 in 12. The top was rounded, but for a depth of 2½ ft. on the back it sloped 1 to 1; at the bottom it was curved to the arc of a circle so as to discharge the water in a horizontal direction. The spillway was 12 ft. thick below its rounded crest.

The rock on which the dam was built was a fine-grained sandstone. It was solid except for seams in it which might produce good sized leaks and in time might endanger the stability of the dam. These seams were closed by drilling holes below the bottom of the dam about 10 to 20 ft. deep and filling them with cement grout ordinarily under 100 lb. per square inch pressure. A similar course was pursued under the cut off wall in the earth dam described later. The foundation of the dam and abutments was laid from 7 to 8 ft. below the surface of the rock except at the heel of the dam, where it was sunk into the rock 3 ft. deeper. There has been no perceptible leakage under the dam.

This excavation under the dam was from 44 to 60 ft. wide and covered an area of 36,500 sq. ft.

A clay earth dam 20 ft. wide on top was built from the abutments across the river valley. There was considerable gravel in this earth. No trouble has been experienced from leakage or slides. Top soil was removed over the area of the dam to a good sub-soil; selected earth was deposited on the prepared base and leveled, and rolled with 10-ton steam rollers in 6 in. layers. The fill was made 6 in. wider on both sides than the specified width of the earth dam and later cut off to the specified width. Both sides were built with a slope of 2 horizontal to 1 vertical. Before this fill was started a cut off wall was built on the up stream side as follows:

Steel sheet piling was first driven in to solid rock at the proper distance from the center of dam. The earth was then excavated to solid rock and a concrete wall with an average thickness of 30 in. was built up to elevation 928. Heavy expanded metal was placed in the top of this wall and bent over to connect with reinforcing in a 9-in. concrete slab built in 25 ft. sections on top of the slope of the bank. This slab extended up the slope of the bank to within 4 ft. of the water line, from which point the slope was paved with sandstone blocks 18 in. deep to the top. The joints were filled with cement grout. On top of the earth dam was built a concrete wall 2 ft. thick and 2 ft. high. Back of this wall a 15 ft. sidewalk was laid.

The lake formed by this dam impounds 10 billion gallons and covers 1,700 acres. It is 6½ miles long and varies in width from a few hundred feet to 1 4/10 miles wide. In a dry year the dam will furnish 80 million gallons a day.

The construction of this dam involved the building of 8 miles of highways, five bridges with a total length of 3,247 ft. and 5 miles of oil pipe line. The entire cost of the project was $1,250,000. This was entirely borne by the city of Youngstown and the work was done under the general direction of the City Engineer's office.

The Nashville Plan for Bringing the Engineer Into Public Life

By R. H. McNEILLY,
Associate Professor of Civil Engineering, Vanderbilt University.

On Jan. 19th the Nashville Engineering Association held its annual banquet at the Commercial Club. At this meeting a live idea was put forward which Mr. Calvin W. Rice, secretary of the American Society of Mechanical Engineers, has named the "Nashville Idea."

The "Nashville Idea," in brief, is a complete scheme for bringing the engineer into public life, and into importance in the civic life of, first, his own community, then of national life.

The Nashville Engineering Association meets at the Commercial Club of the city each Monday at lunch, and the officers of the association are frequently on important committees of the Commercial Club, thus securing a close co-ordination of commercial interests with the work of the Engineering Association.

The association, through its committees, has made special studies of local conditions and improvement and then using as a lever the power of the Commercial Club, has fought these measures through politically.

Some of the local measures which it has in particular carried through are: A new building code; a bond issue for sewers; the employment of a board of engineers from eastern cities to report on proposed improvement in the city water system.

The association has made, through a committee, an exhaustive report on the power possibilities at Muscle Shoals on the Tennessee River. They raised money for the printing and distribution of this report from all cities in the Tennessee Valley, and by practically maintaining a lobby in congress for 3 or 4 months secured the location of the government nitrate plant at this point.

This was a successful national measure.

The association maintains a close co-ordination with the engineering school of Vanderbilt University and has a student branch at the university which meets once per month with the Nashville Association and once per month at the University thus bringing the student of engineering, when he first enters college, into contact with civic problems, and begins his training to play his part in civic affairs.

This, in short, is the "Nashville Idea"—co-ordination of the civic forces of the city with the engineering ability of its citizens.

The new goal which the association has set for itself is adequate engineering endowment for Vanderbilt University.

The association feels that in the present day, all of the serious problems before the government are those of city life, and that 75 per cent of these problems depend for their solution on engineers. That the training of engineers is vitally important to the continued success of our democracy. We have fought to make the world safe for democracy. We must now save this democracy for the world, and we will not do so without well-trained engineers.

This is the "Nashville Idea."

Rules for Operation of Army Sewage Treatment Plants

About 150 sewer systems and sewerage disposal plants have been built throughout the United States by the construction division of the army. In most cases, the treatment works consist of sewage tanks and chlorination only. In a few cases, however, it has been necessary to install trickling filters and secondary tanks. One of the latest installations of these army plants is that at the general hospital at Fort Sheridan, Ill. The treatment works here consist of a diversion box, septic tank, dosing chamber, trickling filter, chlorinating and humus chamber, secondary settling tanks and sludge drying beds. The main features of the Fort Sheridan plant were discribed in a paper presented at the recent meeting of the Illinois Society of Engineers by Mr. H. R. Abbott, who was supervising engineer in charge of the construction. In connection with this paper Mr. Abbott gave the following extracts from the general rules for the operation of the plant:

The attendant should carefully inspect all parts of the plant at least once each day.

He should at once report to officer in charge of the plant any unusual condition or imperfect functioning of any part of the plant.

Screening and Detritus Chamber: The screens or racks should be raked at least once each day or more often if necessary to keep them in good condition and to prevent the backing up of sewage in outfall sewer. Screenings should be removed from platform immediately after completion of raking and disposed of either by burial or by incineration. As soon as screenings are deposited in trenches, they should be covered with at least 3 in. of earth or should be sprayed during warm weather with a 10 per cent borax solution in order to prevent the breeding of flies.

Where detritus chambers have been provided, great care should be exercised to keep them free of heavy deposits. It is essential that they should be thoroughly cleaned at least once each week. Where such chambers are provided with a blow-off, the detritus should be drawn off daily. This operation will obviate any danger of clogging of blow-off line. The material removed from detritus chambers shall be disposed of by burial as required for screenings.

Sewage Tanks: It is desirable to maintain an equal rate of flow through all tanks in service. To accomplish this, in certain cases it may be necessary to adjust the valves on inlet pipe lines or gates in distribution chambers. A uniform depth of flow over the effluent weirs of all tanks in service is an indication of proper distribution of flow in the several tanks.

Number of Tanks to be Used: Where two or more tanks are provided, the operator shall use at one time only such number of tanks as will provide an average detention period of not less than 6 hours nor more than 12 hours. In computing the detention period the entire capacity of each tank shall be used.

Rotation of Tanks in Service: In case the number of tanks is in excess of requirements, as described in the preceding paragraph, tanks should be operated in rotation, a period of two weeks' use to be followed by as long a rest period as conditions allow.

Operation of Tanks: To produce the best results, care must be taken that all parts of the tank, including all baffles and other concrete surfaces, be kept clean, by hosing and use of squeegee.

During the first few months of operation it is essential to break the scum daily by means of a hose stream or by aid of some mechanical device in order to avoid the formation of a heavy scum, as soon as bacterial action has become vigorous.

When the bacterial development in the tank, especially the first compartment, has reached a certain stage, hosing is required less frequently.

Scum formation varies considerably in different tanks, being dependent on certain characteristics of the sewage.

Lime Treatment for Acid Sewage: Wherever the litmus test shows an acid reaction in the raw sewage, milk of lime should be added in quantity sufficient to neutralize this acidity. The quantity of lime required will vary from 100 lbs. to 500 lbs. per 1,000,000 gals., depending upon the degree of acidity of the sewage.

Transfer of Sludge: At times it may become necessary to transfer partially digested sludge from the first compartment of a tank to succeeding compartments, in order to facilitate digestion. This is especially important where tanks are being used to their maximum capacity. The transfer may be accomplished either by means of a gasoline operated diaphragm pump, or by drawing down the liquid in the last compartments through the draw-down valves and then transferring sludge through the sludge lines.

Where sludge pipe system is provided with a direct connection with a water distributing system it is desirable to agitate the sludge in the bottom of the first two compartments by the introduction of water through the sludge lines. This should be done in five minute periods, weekly.

Drawing of Sludge: Sludge should be drawn only when thoroughly digested. Sludge in the last compartment should be removed frequently in order to obtain an effluent low in turbidity.

Sludge shall be drawn into sludge beds to a depth of not more than 12 in., after which sludge lines shall be drained or filled with water or clarified sewage, to avoid formation of heavy deposits. Digested sludge should dry to a spadeable condition in three to six days, according to weather conditions. When sufficiently dried, the sludge should be removed from the beds and deposited in fills or disposed of as fertilizer.

Siphon Chamber: Very little difficulty should be experienced with the functioning of the siphon chamber. The walls of the chamber should be kept clean by squeegeeing or hosing, and fine screens located in the channel leading to the siphon chamber should be inspected daily.

Sprinkling Filters: Great care should be taken to keep all parts of the filter clean and free from debris. The effluent channel should be cleaned weekly, and the underdrains flushed out when necessary to remove visible deposits.

All nozzles should be inspected daily and cleaned where necessary, and broken or bent spindles replaced.

Experiences in Imhoff Tank Operation

Imhoff tank operation in Wisconsin has not met with a great deal of success when the tanks were designed according to the ordinary practice. However, when the tanks were so designed that the influent to the tank is admitted in the lower compartment, or sludge chamber, the results are greatly improved, according to W. G. Kirchoffer, Sanitary and Hydraulic Engineer, Madison, Wis., in a paper read by him before the Thirty-fifth Annual Convention of the Illinois Society of Engineers, held recently at Urbana, Ill. The matter following is condensed from Mr. Kirchoffer's paper:

The first use Mr. Kirchoffer made of the Imhoff tank was for the waste from a small creamery. It soon developed, however, that this design was not adapted for this sort of waste, as nearly all of the solids came to the surface instead of settling to the lower chamber.

About the same time three tanks with concrete covers were designed for three municipalities. The designs were approved by the representatives of Dr. Imhoff and the tanks constructed. The first troubles began at the city of Waupon, Wis., where it was found almost impossible to draw off the sludge. Black putrescible liquid would come, but nothing else.

In the next few designs, concrete covers to the tanks were omitted and the sludge pipes made as large, straight and short as possible. The difficulties still persisted, though, sludge accumulating on the surface of the upper chamber, with little or no sludge coming out the sludge pipe. The effluents of these plants were at no time clear, and were always highly putrescible.

A tank was next constructed at the city of Ripon, designed on somewhat different lines. The sewage is domestic with some creamery and wool wastes. The sewage was delivered to the tank at the middle of one side of the tank, flowed around in both directions and passed out the opposite side of the tank. Two sludge wells and two pipes and one gas vent were provided. After about five months' operation, an attempt was made to draw off sludge. It was found that there was sludge and scum on the tank surface to a depth of three feet or more. In a day or so the gas vent began to foam and run over into the upper story. Nine hundred and seventy-six wheelbarrows full of sludge were removed from the surface of the tank, while in the top of the sludge compartment the sludge was 16 ft. or more deep.

After making some experiments, a tank was constructed so that the raw sewage could be introduced into the lower or sludge chamber, upward through the slots, thence longitudinally through the upper chamber to the outlet. The tank has been in operation for a number of months and, so far, the effluent has been found to be clear but with a very slight odor. The sludge can be drawn freely.

The design of the tank at Ripon was then changed so that the raw sewage could enter through the gas vent. The plant has been operating satisfactorily to the present time.

No chemical analyses of the effluent of any of these plants were made, so that any conclusion to be drawn from this experience must be based on operating results. In these examples at least, it is shown that the effluent, although it may be more putrescible than from a properly operated Imhoff tank, is handled by the filters more readily than the effluent from the plain Imhoff tank.

These experiences have taught that sludge can be much more readily digested by discharging the crude sewage into the sludge chamber than into the sedimentation chamber, and that foaming is prevented. Imhoff tank designs may be applicable to the conditions in Germany where there may be only slight amounts of grease and oils present or where the sewage is very stale, but according to my experience, they are not adapted to the conditions in Wisconsin, where the sewage is fresh and contains greasy matters.

Metal Flume Has Removable Section for Passage of Dredge

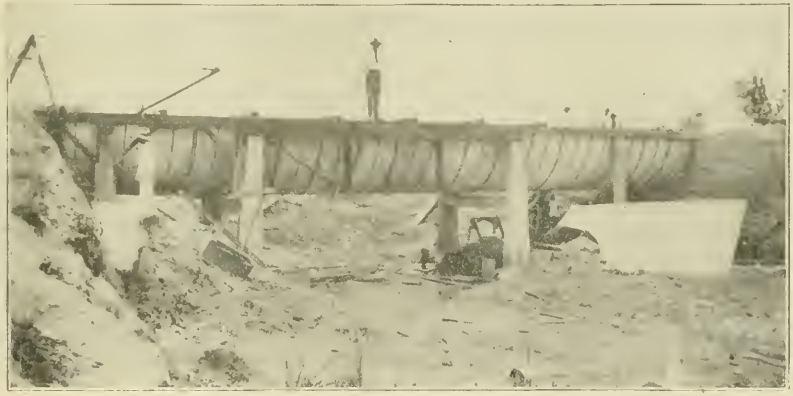
An interesting feature of a recent Armco flume installation in Cameron County Water Improvement District No. 2, at San Benito, Tex., is the provision made for the passage of a dredge. The flume carries high line water over a low line canal, which is fed directly from the river to gravity, and as a result silts up very rapidly. This silt is removed by a hydraulic dredge, which must have free passage up and down the canal. To allow this the new flume was constructed with a removable section. This feature is described in The Highway Magazine as follows:

The concrete piers are placed on an 18-in. reinforced concrete slab, this slab in turn resting on six round pine piles, driven to a 14-ft. penetration.

The piers are so placed as to leave a 20-ft. clear passageway between them. To support the flume across this span an 8-in. by 16-in. trussed beam was used. This beam is fastened at each end by a 1-in. bolt embedded in the concrete piers.

When it is necessary to remove the flume the supporting rods are removed and the flume is taken out one section at a time. The nuts are then removed at each end of the beams and the beams lifted off the bolts and piers. After the dredge has passed, all that is necessary is to replace the beams, fasten the sections of flume in place and grout the joints. The flume is then ready for use.

Three handy men can remove or replace the flume in half a day, and since it is necessary to pass the dredge through about once a year, this answers all purposes.



Movable Section of Metal Irrigation Flume Spanning Canal.

Method of Cleaning Clogged Lime Water Supply Line at Cincinnati Filter Plant

It was discovered during the spring of 1917 that the 20 and 24-in. cast iron pipe which conveys the lime water from the saturators in the chemical house to chamber "B" near the head house of the filtration plant of Cincinnati, O., was evidently clogged with sediment preventing the required amount of lime water being delivered to this chamber. Examination was first made of the 20 and 24-in. line in the chemical house and it was found that there was a deposit of lime sludge sufficient to close about ⅔ to ¾ of the cross section of pipes. As much of this deposit as possible was removed by hand and flushing. An investigation of the 24-in. pipe extending in front of the head house into chamber "B" demonstrated that this part of the line was in equally as bad condition. The methods employed in cleaning the pipe are described in the recently issued report of the Cincinnati Water Department for the years 1917 and 1918.

After numerous attempts had been made to increase the velocity of lime water through this line, thinking perhaps an increased velocity might have a tendency to gradually clear the pipes, it was finally concluded that the total length of pipe was in practically the same condition as parts that had been examined. Arrangements were then made to thoroughly clean the total length of pipe and free it from all obstructions or deposits. In order to facilitate this work of cleaning the line, a brick chamber was constructed around the 24-in. tee near head house, a 24-in. cross replaced the 90-degree elbow at the chemical house, which cross including a 24-in. gate valve was installed in a brick chamber. A 20-in. gate valve was located at end of 20-in. pipe in chemical house. The blank end of the 24-in. tee and the two blank ends of the 24-in. cross were constructed with blank covers to facilitate work of cleaning and for any future examinations and cleaning of the line. There was also located on the 90-degree elbow in the bottom of Chamber "B" one vertical 12-ft. length of 24-in. pipe, the elevation at top of this pipe being 110. This extension permitted the continuous operation of the plant while work of cleaning was in progress as the water level in Chamber "B" could safely be maintained at elevation 109.5; meanwhile the lime water required was fed through an auxiliary 8-in. line into Chamber "E."

The first section of pipe cleaned was the 20 and 24-in. in the chemical house from end to the 24-in. cross by means of go-devils of 12, 16 and 20 in. diameter, which were attached to a cable and drawn through by means of a crab. The next section of the line cleaned was that in front of the head house leading from the 24-in. tee to Chamber "B." On account of the solidity of the deposit, the machine for cleaning became fast and it was necessary to excavate and cut the line and remove machine.

The final section of the 24-in. line was about 584 ft. in length, where extreme difficulty was encountered in rodding and getting the line through the pipe for attaching the cleaners. It was found impossible to float a line through this pipe and attempts to rod it with ½ and ¾-in. pipe proved futile. The line was then cut about midway and finally succeeded in rodding and passing wire through the line of pipe.

A special go-devil was finally designed, consisting of fish-hooked shaped rods fastened to a central bar. This was placed in front of one or two go-devils, all in tandem on a wire cable. By winding this cable over the drum of a hoisting engine, and operating the latter very slowly, it was possible to drag the cleaning apparatus through the pipe. By repeating this operation many times, the sludge and incrustation within the pipe were finally removed.

Unloading Coal at Plant of Gillespie Motor Co. with Five Scoop Conveyors.

The material was removed from the chamber at 24-in. tee and 24-in. cross after each pull of machine. A final pull was made through the long length of pipe using the hook machine to which was attached a wooden swab or piston covered with hose to thoroughly clean the line. After each pull as well as final pull the line was flushed.

Examination of this line will be made regularly every year and kept free of deposit, which work can be easily handled in the future.

Handling Coal a Distance of 150 Ft. With Portable Conveyors

An interesting application of scoop conveyors for storing coal has been made at the plant of Gillespie Motor Co., Paterson, N. J. Five machines are used to unload coal from hopper bottom cars direct to the storage pile. Four of these are 12 in. wide by 24 ft. long, the other one being 12 in. by 20 ft. Each is equipped with its own electric motor and can be operated singly if desired. The first machine is practically self-feeding from the hopper doors of the car and the other four may be swung around at any angle to cover a wide storage area. Five machines arranged in this manner can be operated by one or two men. Where desired, one machine can be used to load an electric storage battery truck to convey the coal directly into the boiler room. The conveyors are manufactured by the Portable Machinery Co. Inc., Passaic, N. J.

Personals

George Garrett has been appointed city engineer of La Grande, Ore.

Reuben Bragstad has been appointed assistant city engineer of Sioux Falls, S. Dak.

Frank R. Shaw, City Sanitarian of Dallas, Tex., has resigned and will engage in consulting engineering.

Lawrence Reinicker has been appointed designing engineer in the engineering and construction division of the water department of Baltimore, Md.

Alexander C. Humphrey has been elected president of the American Institute of Consulting Engineers. The other officers are: S. Whitney, vice president, and F. A. Molitor, secretary and treasurer

H. S. Mullican, who has served Davidson County, North Carolina, for several years as county highway engineer and superintendent, has resigned to accept a similar position with Davie County at a salary of $300 per month.

G. P. Boomsliter, associate professor in Theoretical and Applied Mechanics of the engineering department of the University of Illinois, has resigned from the faculty and accepted a position as head of the department of Engineering at the University of West Virginia, at Morgantown.

Thomas J. Wasser, county engineer of Hudson County, New Jersey, has been elected president of the New Jersey State Association of County Engineers. The other officers are: Vice president, A. H. Nelson, County Engineer of Atlantic County; Secretary, Harry F. Harris, County Engineer of Mercer County, and treasurer, Alvin B. Cox, County Engineer of Middlesex County.

R. A. Harbaugh, estimate cost engineer Pittsburgh Filter & Engineering Co., has been elected president of the Oil City, Pa., chapter of the American Association of Engineers. Other officers elected were: First vice president, B. B. Weber, City Engineer, Oil City; second vice president, C. L. Olmstead, Assistant Division Engineer, B. & A. V., Division P. R. R.; secretary, A. C. Burwell, Civil Engineer, United Natural Gas Co.; treasurer, S. L. Connell, General Superintendent, Pittsburgh Filter & Engineering Co.

Arthur P. Davis, director and chief engineer of the U. S. Reclamation Service, has been elected president of the American Society of Civil Engineers. Mr. Davis was born in 1861. He was graduated from the Kansas State Normal School in 1882, and entered the employ of the U. S. Geological Survey the same year. In 1907 he succeeded F. H. Newell as chief engineer of the U. S. Reclamation Service and in 1915 became director of the service. He was a member of a board of engineers which accompanied President-elect Taft to investigate conditions of the Panama Canal work and to report upon the feasibility and safety of the Gatun dam. As consulting engineer he has served the Isthmian Canal Commission, the Russian Government and several large irrigation projects in American colonies.

Trade Publications

The following trade publications of interest to engineers and contractors have been issued recently:

Liquid Chlorine. Electro Bleaching Gas Co., 18 E. 41st St., New York City. 18 page catalog describing the nature, uses and advantages of liquid chlorine and methods of application.

Valves. Nelson Valve Co., Chestnut Hill, Philadelphia. 156 page catalog and price list covering bronze, iron and steel valves in gate, globe, check and non-return patterns, including types for practically every class of service found in power plant work, industrial establishments and large building construction.

Centrifugal Pumps. Goulds Manufacturing Co., Seneca Falls, N. Y. 36 page bulletin. Contains data first issued in letter form for use of the selling organization of the company and now reprinted for general distribution. Much useful information on theory, designs, testing, etc., of centrifugal pumps is given.

Industrial Notes

The Chicago Pneumatic Tool Co. on Jan. 21 and 22 held a general conference of executives, plant and branch managers and salesmen at its Detroit plant, Second Ave. and Amsterdam St., on the occasion of the formal opening of a large five-story addition.

General Tractors, Incorporated, announces the appointment of Frank W. Cloman as advertising manager. Mr. Cloman has just been released from the Army where he served in France with the Engineers. He was previously connected with the Dart Motor Truck Company of Waterloo, Iowa, the Wm. Galoway Company and Continental Motors.

During the absence in Europe of A. M. E. Johnstone, the Wallace & Tiernan Co., Inc., has appointed Gilbert H. Pratt acting district sales representative for New York, New England and northern New Jersey. Mr. Pratt was formerly chief chemist of the New York Continental Jewel Filtration Co., prior to which he was chief of the Rhode Island State Department of Health, after several years' connection with the Massachusetts Health Department.

Railway and Excavation Monthly Issue

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The four rotated special monthly issues and 4 quarterly issues of E. & C. (52 in all) entirely cover the civil engineering and contracting field at $3.00 a year. The special quarterly issues relate entirely to foreign engineering and construction practice. The *articles* in the first two issues of each month completely cover the municipal engineering and contracting field. The *articles* in the first and fourth issues of each month completely cover county engineering and highway engineering and contracting. The *articles* in the 3rd and 4th issues of each month completely cover steam and electric railway location, design and construction. See the "masthead" on the first page of the Weekly News Section for information about our weekly contract news.

Roads and Streets—1st Wednesday
(a) Roads
(b) Streets
(c) Street Cleaning
(d) Municipal Miscellanies
(e) Management and Office System

Waterworks and Hydraulics—2nd Wednesday
(a) Waterworks
(b) Sewers and Sanitation
(c) Irrigation and Drainage
(d) Power and Pumping
(e) Management and Office System

Railways and Excavation—3rd Wednesday
(a) Excavation and Dredging
(b) Rivers and Canals
(c) Quarries and Pits
(d) Railways, Steam and Electric
(e) Management and Office System

Buildings and Structures—4th Wednesday
(a) Buildings
(b) Bridges
(c) Harbor Structures
(d) Miscellaneous Structures
(e) Properties of Materials
(f) Management and Office System

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"Everything Is Engineered These Days"

H. F. Hill, vice-president of the Chicago Telephone Co., in a recent interview said:

> Everything is engineered these days. We lay a cable; it is engineered. We put in a switchboard; it is engineered. My desk here was engineered before it was made—even the number of tacks holding down the cover was engineered. We engineer production and we engineer installation; we engineer everything. We put up a telephone pole—it has to be engineered to see if it should be out ten feet this way or five feet that way.

This was a prelude to Mr. Hill's statement that "human engineering" has now become part of the policy of his company. We have quoted him, however, not for the purpose of discussing scientific welfare work, but to comment upon the statement that "Everything is engineered these days."

In the management of the Bell Telephone Companies it is true that everything—or nearly everything—is scientifically planned, and therefore engineered. But, unfortunately, the Bell companies are not typical of the country as a whole. Even our railways are not "engineered" in all their departments. And as for political affairs, engineering has scarcely been tried.

Nevertheless engineering methods are being adopted at a rate that is encouraging when contrasted with prewar years. Probably the war itself is largely responsible for the rapid spread of engineering. Engineering professors tell us that the unprecedented size of their freshman classes is attributable to what the war has taught the public about applied science—engineering. Popular magazines and daily papers have vied with one another in depicting the dramatic achievements of our scientific men during the past five years. Take up any copy of Literary Digest, Saturday Evening Post, or The American Magazine, and there you will find not one but several stories—fact or based on fact—glorifying scientific achievement.

When a young man continuously hears praise of any profession, he is apt to aspire to become one of its members. So all this free publicity that the profession of engineering has recently received, is bearing the fruit that might have been predicted. Many of our hundred or more engineering colleges have had to turn away would-be students.

Some practicing engineers, and even a few engineering teachers, have expressed doubt as to the wisdom of encouraging so many men to enter engineering colleges. They foresee an overcrowding of the profession. Of course, if the old, narrow conception of engineering is to prevail, then steps should be taken to discourage the present rush of thousands to secure an engineering training.

For sixteen years Engineering and Contracting has been preaching a new ideal, an ideal

28 Pages=40 pages

The 28 pages of articles in Engineering and Contracting contain as many words as 40 pages of the size and typography commonly used by other engineering periodicals. Ours is the same size of type and type-page as that of The Literary Digest—easily read, yet giving a large volume of reading matter per page. Our 28 pages of articles would fill 112 pages of the standard 6x9 in. text-book. It would take 10 such books of 580 pages each to hold all the articles printed each year in Engineering and Contracting, to say nothing of our weekly construction news.

that is expressed in the title of this editorial. We have hoped and believed that in time it would come to be generally agreed that, wherever economics is involved, everything should be engineered. Our conception of engineering originally was, and still is, a conception that implies the possibility of applying scientific methods to every branch of human endeavor. With such a conception there inevitably goes the belief that the profession of engineering can never be overcrowded. Indeed, it becomes apparent that, educate as many engineers as you may, still the supply will fall short of the latent demand.

We qualify the word demand by use of the word latent, for we are well aware that demand is not always immediately in evidence. Often it requires effort to arouse demand, but such effort may be infinitesimal compared with the energy of the demand then made manifest. Just as a moderate amount of publicity has created a great demand for engineering education, so can the demand for engineering services be enormously increased by publicity.

Why Experiment With Government Ownership Here Until the Proposed Canadian Experiment Is Made?

Most Americans that believe in government ownership of railways will concede the wisdom of trying the plan on a moderate scale before making it universal. If so, they should be willing to await the results from the experiment that Canada is about to make.

Philip Kinsley, special correspondent of the Chicago Tribune, said, on Feb. 7:

> Canada is just getting fairly launched upon the greatest adventure in government ownership of railways that any nation ever has attempted.
>
> With the taking over of the Grand Trunk Railroad, including its 1,800 miles in the United States, this people will own 23,375 miles of railroad, representing an investment of more than $1,300,000,000; a great telegraph system, a national express service, hotels, and a merchant marine with twenty-three vessels in commission and sixty steel vessels under construction.
>
> Three men are running this vast enterprise, which has been taken entirely out of politics and out of the hands of Parliament. The method is a corporation method. The entire system, consisting of thirty-three companies and those that are to come in, is embraced in the incorporated Canadian National Railway Company.
>
> It is certain that there will be a deficit in the government roads for years, but eventually, with strict railroad management and economy, the people hope that it will develop into a paying proposition. The deficit this year will be in the neighborhood of $30,000,000, payable out of the consolidated revenue fund.

Canada has long owned a large railway mileage, and it has been a continuous source of loss from the very beginning, but the advocates of government ownership have argued that the annual deficits did not disprove their theory. They have contended, for example, that the Intercolonial Railroad was built to develop new Canadian territory, and could not be expected to show a profit. Without doubt there was merit in such an argument. But now that Canada is about to take over all the railways—those that serve well developed territory as well as those that serve new territory—we shall soon be able to judge the ability of the Canadian government to manage a great railway system.

Whenever Americans have pointed to the failure of European governments to manage railways economically, the reply has been that conditions in Europe are not comparable with conditions in America. The argument was weak, for it has always been feasible to make proper allowances for differences in wages, lengths of haul, etc. Now, however, we shall see more than 23,000 miles of railway, representing an investment of nearly one and a third billion dollars, using American rolling stock and American methods of operation, under the direction of a North American government.

Wages in Canada have never differed greatly from those paid in America. Canada also is "a country of magnificent distances." In politics it is as clean as we are. Its civil engineers are as able as ours. Its business managers are not less astute. Therefore if the Canadian government can not excel our privately-owned railways in point of low cost for equal service, it is safe to say that our own government could do no better.

We welcome this large scale experiment in government ownership of railways by the Canadians, for the same reason that we welcome the experiment that Seattle is making in street railway ownership. It is the part of wisdom to make such experiments before adopting universally the theories upon which they rest. Progressive business men conduct their business in the same manner, making experimental changes on a moderate scale—never on a ruinously large scale. Why should not governments do the same? Canada has resolved to be our experimental laboratory in railway ownership. America should be grateful to Canada for saving us the expense of making this crucial experiment on so large a scale, even as other cities should thank Seattle for its municipal ownership experiments. And we may all thank Germany and Austria for the grand test to which Marxian socialism is about to be put.

If an inventor claimed to have devised a machine that would offset the pull of gravity, and offered to demonstrate it at his own expense, who would insist upon assuming the entire expense of the experiment without being guaranteed an interest in the patent? Let an inventor of a new system of government appear, and let his system rest upon the theory that the pull of selfishness can be completely offset by the new governmental system, and millions of men can be found who will insist upon scrapping all governmental machinery in the world, before the new system has been given a thorough trial in a state even as large as Rhode Island! Such is the logic of the man who has never managed anything successfully, and has therefore failed to learn one of the basic principles of economics: Scrap what you have got, only when tests have proved that there is something better to be had.

A Motor Vehicle for Every Ten People

Ten million motor cars and trucks will be in service in America by the end of 1920, according to the statisticians of the B. F. Goodrich Rubber Co. There are now more than seven and a half million registered in the 48 states, which is an increase of 26 per cent over the preceding year. There are eight states that have more than 300,000 cars and trucks each, namely: New York (600,000), Ohio (511,500), Illinois (478,450), California (441,100), Pennsylvania (414,485), Iowa (362,000), Michigan (346,218), and Texas (330,100).

A few years ago when California and Iowa passed the mark of one motor vehicle per 10 people there was a great deal of comment upon the possibility of such a high ratio being reached some day by the nation as a whole. It is evident now that one motor vehicle to every ten people will be the average in America within about a year!

The following are the numbers of people to each motor car in certain foreign countries:

England (180,000 cars)	270
France	400
Germany	680
Italy	1,000
Austria	2,700
Russia	5,300

In America there are about 10 motor cars to every motor truck, but the motor truck output is increasing even more rapidly than the motor car output. In 1904 America produced only 400 motor trucks, whereas in 1918 the production was 227,000. Astonishing as this increase has been, it is dwarfed by the rate of increase of tractors, of which the output was about 30,000 in 1916, as compared with 315,000 in 1919. Most of the tractors have been sold to farmers, but many have been sold to contractors.

Freight cars on steam railways outnumber passenger cars about 30 to one. The time will come when motor trucks will outnumber motor cars. How soon this will happen depends largely upon the rapidity with which roads and streets are improved.

Iowa Road Work Calls for 11,534,000 Cu. Yd. Excavation.—The 1920 primary road construction program of the State Highway Commission of Iowa involves road grading requiring 11,463,132 cu. yd. of earth excavation and 71,748 cu. yd. of rock excavation.

Waterproofing Railroad Structures

To the Editor: The writer has read with much interest your discussion in your Dec. 17 issue, and Mr. Gardner's criticism in the Jan. 21 issue, of the waterproofing methods suggested by Mr. Joseph Ross in a paper before the Municipal Engineers of the City of New York.

It seems difficult to believe that some of these methods suggested could have been intended as methods for "Waterproofing Railroad Structures" and that the title must be a misnomer.

If there is any principle that the last 20 years' experience in waterproofing of railroad structures has emphasized, it is the necessity of absolute plasticity and elasticity in the waterproofing membrane used.

The constant vibration and deflection of the structure subjects the membrane to intermittent tensile stresses and the membrane must have elasticity not to rupture under them. Moreover, with the constant necessity for flashing around stiffners, brackets, over abutments, etc., make any material that is not absolutely pliable, absolutely inadmissible.

This was one of the causes of the failure of the formerly largely used felt membranes. Even they were not sufficiently pliable to be flashed and bent and turned, as is so often necessary without very skillful workmanship and very rigid inspection. It is a fact, too, that temperature changes have a very great effect on the disintegration of waterproofing materials. The disrupting effect usually occurs from contraction from low temperature, and unless the waterproofing medium used will remain elastic at low temperature, it will inevitably disrupt from the contractive effect of the material to which it is applied.

To take up the methods suggested, how would it be possible to flash a metallic reinforcement around the stiffners and over the rivet heads of a through girder bridge along the juncture line of floor and girder, even if it were possible to obtain a metallic mesh which would lay sufficiently flat on a level surface? None that the writer has ever seen would even do this without requiring the use of a compound which would have to be laid on in a thickness of ½ in. or more to cover the fabric.

As to the ready prepared membranes, the statement is made "the ready membranes might be used to good advantage on subways and other large or difficult engineering works, if a good system of angles and connections with the flat work could be devised." That is exactly the trouble which has been the trouble for many years. It is easy enough to get a flat surface tight, but the problem has always been to waterproof the joints and connections, and it is at these joints that absolute elasticity and pliability are essential.

The same objections apply to the second form suggested, of flat or corrugated sheet iron. Regardless of expense, it will be absolutely impossible practically, to adapt any such material to exigencies of railroad bridge construction. They would be absolutely inelastic, and could not give under temperature stress, except by breaking at the joints, if it were possible even to make joints.

As to the idea of a lead sheet, this might be a little more pliable, but again the question of joints and flashing would present impossible difficulties and, as said before, it is always at joints and at flashing points where leaks occur. No system that does not consider this as the primal problem to be solved can even be considered in the waterproofing of railroad structures. The use of lead, too, would, of course, be absolutely prohibitive from a cost standpoint.

The use of a clay envelope for any structure subject to temperature changes would, of course, be utterly out of the question. The clay layer would have absolutely no tensile strength and would be cracked into a thousand pieces from the temperature change and vibration.

With regard to the bituminous mastic sheet, this was tried many years ago and was found utterly inadequate for the reasons above outlined; i. e., inelasticity and inability to make secure joints and flashings. As far as the writer knows today, it is used nowhere, except possibly as a covering for a membrane.

The same trouble applies to the brick in mastic, or to an envelope of a mixture of clay and cement, as suggested.

In any structure subject to vibration or temperature change, the question is not at all one of obtaining an impervious material, because however impervious such a material might be, it would soon be cracked and broken, and its waterproofing value absolutely rendered void. If this were not the question, it would be a very simple matter to waterproof railroad structures which are either of concrete throughout, or in which the floor base is concrete where steel structures are used. It would be a very simple matter to obtain an impervious concrete base and this could be done through the addition of an integral waterproofing material, some of which, without question and beyond dispute, do render concrete impervious, but it is always the fissure which occurs in the concrete from the temperature changes and vibration which admit the water.

It is absolutely necessary, therefore, to waterproof railroad structures with an elastic membrane, and a membrane which should be elastic not only at high temperatures, but at low temperatures.

The reason the felt membranes have largely been superseded by the fabric membranes is because of their lack of elasticity, particularly at low temperature, and also because of their lack of pliability.

The waterproofing value of the felts was largely due to their impregnation with pitch or asphalt. The impregnated parts loose their elasticity at low temperatures and under this condition, break from the contraction and vibration.

The cementing materials used to attach the sheets suffer the same defect. This has led to the adoption of the fabric and the attempt to use with them compounds which will retain their elasticity even at low temperatures.

This brings us to Mr. Gardner's discussion, in which the writer finds one point at least which seems illogical, in regard to the relative values of burlap and cotton duck. In regard to the fabric, it is stated that "It permits the piling up of a thick bed of the plying cement (which is the real waterproofing), and it holds this cement in place and makes it stay put." If the plying cement is the real waterproofing, why is the nature of the fabric used so vastly important? Conceding all that may be said as to the disintegration of the burlap by the water and alkali, how is the water to reach the burlap if the compound is really waterproof and elastic, and even if it does, what harm is done after the fabric has performed its function of providing "the piling up of a thick bed of plying cement?"

It would seem to the writer that if the compound used with the fabric is truly waterproof and truly elastic at low temperatures, then the compound is the primal factor of the membrane and the nature of the fabric is of secondary importance.

If, on the other hand, the compound cannot be relied upon to retain its elasticity, then, of course, dependence must be placed on the fabric to assist in the waterproofing function.

The cotton duck is very much more expensive than the burlap, and there is no reason why this economy should not be effected with compounds which possess elastic and non-hardening properties that render the function entirely secondary.

There is no question, however, as stated by Mr. Gardner, that the railroad companies are using today membranes composed of fabric and compound, and that they have proven far more effective than any previous type of membrane used, for the reasons that they are elastic and pliable and that these two functions are absolutely essential to success.

A. H. RHETT,
Engineer of Structures for construction
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New York.

Michigan Short Course in Highway Engineering.—The sixth annual short course in highway engineering will be held Feb. 23 to 27 at Ann Arbor, Mich., by the University of Michigan. The course will be under the direction of the College of Engineering and in co-operation with the Michigan State Highway Department.

Sampling Gravel with Orange Peel Bucket.—A small orange peel bucket is used by the Coon River Sand Co., Des Moines, Ia., for sampling sand and gravel deposits. The bucket is suspended from a tripod and sinks a well inside of a lining made of sewer pipe.

Labor Saving Devices in Maintenance of Way Work

Much useful information on labor-saving devices for track work was given in a committee report adopted at the last annual meeting of the Roadmasters and Maintenance of Way Association. The following is an abstract of the report:

Mechanical Tie Tampers.—It was the committee's opinion that no tool in recent years furnished to the track forces made its appearance at a more opportune time or filled in a greater void than the power-operated tie tamper. It may be reasonably said it is here to stay, although for several reasons it has been a somewhat difficult implement to introduce, the principal reason being the cost, and next the sceptical way in which many trackmen looked at anything capable of tamping ties other than the tamping pick or tamping bar in the hands of a competent laborer. Now, however, owing to the growing scarcity of labor and the inefficiency of many of those available for track work, the mechanical unit is brought into play and hailed gladly by those interested in track maintenance.

The great majority of those who have used a tamping machine and given it a fair trial will testify to its wonderful value as a labor-saving device. It is the committee's observation that the machine work is more uniform and better than track tamped by hand. It has been proved that a tamping machine is of particular value around frogs and switches, water pans, tunnels, etc., as it is possible to tamp with it in places which cannot be reached by a tamping bar or pick.

Carefully compiled figures for hand and machine tamping from several railways covering a period of three seasons follow:

For a 2-tool machine: 1 foreman, 10 hours at 32 ct., $3.20; 4 men, 10 hours at 22 ct., $8.80; 12 gal. gasoline at 24 ct., $2.88; total, $14.88.

Without machine: 1 foreman, 10 hours at 32 ct.; $3.20; 4 men, 10 hours at 22 ct., $8.80; total $12.

Cost per mile of track without machine, 32 days at $12, $145.92; cost per mile of track with machine, 16 days at $14.88, $238.08; balance in favor of machine, $145.92.

For a 4-tool machine the comparison between hand tamping and mechanical tamping was as follows:

Hand gang and foreman, 16 men, 8 hours, tamped 500 ft. of track; machine gang and foreman, 6 men, 8 hours, tamped 528 ft. of track; saving of 10 men and 80 hours for machine.

Expense: Hand gang and foreman, 16 men, $43.50; machine gang and foreman, 6 men, $18.50 (cost to run $6.95); $24.45; saving by machine, $18.05.

Fixed charges are given as follows as near as it is possible to get them: Depreciation at 10 per cent, interest 5 per cent, repairs 5 per cent, total fixed charges 20 per cent.

Experience during the four years this machine has been in use teaches that, under normal conditions in the northern states, each machine will be used during the season to tamp about 20,000 ties.

Handling Cinders.—At one cinder pit where crane is used the cost of loading cinders for a year was $0.007 per yard, while at a pit where cinders were loaded by hand the cost was $0.13 per yard.

Cost of unloading cinders by hand, 16 ct. per yard; by dropping bottoms, Rodger ballast cars 7 ct. per yard; steel gondolas, 7 ct. per yard.

Comparative statement of leveling cinders by hand and by the use of spreader: In ½ hour a spreader has leveled 3,000 yds., costing less than $0.001 per yard. To do similar work by hand cost $0.123 per yard.

Rail Handling Machines. As much new rail is received in high-side coal cars it has become absolutely necessary that some mechanical device be used for unloading it. Not on account of the labor shortage alone, but to avaid damage to rails by dropping or rough handling, is such a device needed. The constant demand for quick release of cars, the high cost of work trains, and the few hours of actual work on a line of heavy traffic require a device that will work rapidly with a maximum factor of safety to laborers.

There are rail-handling machines in use which are capable of loading or unloading two cars of rail at the same time. For the operation of these machines nine men are required, one man to operate hoists and four men to each car of rails. The machine is operated by air from the train line. Such machines will unload rails more quickly and without damage to rails or injury to men than could be accomplished by 40 men by hand, thus a saving of 31 men a day is made possible. This machine can also be equipped with tongs to load or unload as many ties with three men as can be loaded or unloaded by 20 men by hand.

Rail Laying Machines. The committee recommends the use of rail-laying machines, especially where rail is of a heavy section, thus relieving tongsmen for other work, the number released depending on the weight of the rail to be handled. To obtain the best results by the use of the machine care should be used to unload the rails as near as possible opposite where they are to be laid.

Snow Melting Devices. The committee is not unanimous in its views as to the benefits to be derived from snow melting devices. The following results were submitted by one of the members:

Two laborers at $3.80 per day, $7.60; royalty on cars, $5 per year (used about 5½ months, 2 cars), 6 ct. per day; 6 gal. hydro-carbon fluid at 11 ct. per gallon, 66 ct., total cost with melting device, $832.

If done by hand: Foreman at $3.35 and 10 laborers at $2.80, total $31.35; 6 rattan brooms at 28 ct., $1.68; total cost by hand, $33.03. Saving by use of device, $24.71.

Another device which can be used successfully for the same purpose is the Hauck snow melting torch.

Switch Plates.—The committee recommended 9 plates under each point of a 15-ft. switch, and under each point of a 16½-ft. switch 10 plates, with a uniform riser of ¼ in. on every tee.

Motor Cars.—The majority of the committee is in favor of the more general use of motor cars, particularly on lines of light traffic, where the length of sections are such as to warrant their use. Therefore it is the committee's opinion that the economy in the use of motor cars decreases in proportion to the additional number of main tracks, which in turn shortens the length of sections. It has obtained the following figures showing the economy effected by the use of motor cars:

Time spent in carrying 14 men and foreman by motor car 14 miles, 30 minutes; for round trip, 1 hour, or total of 15 hours. Time spent for round trip by hand car, 3 hours, or a total of 45 hours, showing a saving of 30 hours in favor of motor cars. There is still a larger saving in the increased energy of the men when they arrive on the job, in the better class of labor attracted, and in the time saved on emergency jobs.

Perhaps the best argument in favor of these cars is in the fact that thousands of them were bought by the men themselves, whose wages were the lowest of all railway employes, they purchasing them to avoid the drudgery of hand cars.

Dump Box for Push Cars.—A home-made dump box for use with a push car is preferable to the flat bottom for the work ordinarily done with the latter. The illustrations show a type that has been found to be a time and labor saver.

Anti-rail Creepers, Etc.—It was the unanimous opinion of the committee to recommend the extensive use of rail anchors, tie plates, guard rail clamps, tool grinders, etc. Many of these devices are practically self-maintaining. Their use prevents excessive cost in track maintenance and saves labor.

The Horse as a Labor-saver.—On divisions where much ditching must be done by work trains or wheelbarrows teams with scrapers have been tried, with the following results: One laborer can fill scrapers for 2 to 4 teams, according to the distance and advantage of working. Two horses can easily handle a No. 1 scraper, which holds 7 cu. ft., and moves at a 2-mile-an-hour rate, with some delay for filling, turning and dumping scrapers.

One horse of good weight can handle a No. 2 scraper of 5 cu. ft., and after teams are trained a boy not able to do heavy manual labor can drive a team, or when in a narrow ditch, and one horse is used, one boy can take two single horses with a scraper. Dirt can be handled in very short cuts, at the ends of cuts and across the track, for 20 ct. to 25 ct. per yard, and haul it 500 to 600 ft. for 50 ct. to 60 ct. per yard—this with teams at 80 ct. an hour and labor at 35 ct. an hour. By starting teams early in the season, with an experienced man in charge to handle them, all ditching can be done and balance of gang left on other track work. Teams can also be worked in muddy cuts where men won't work. A horse with cart can also be used in terminals to good advantage, cleaning yard, team tracks and driveways.

Where conditions of mowing right of way are such that it is possible to use teams and mowing machines the work can be done by machinery much cheaper than by manual labor.

Ditching Machines, Dump Cars and Spreaders.—When heavy ditching has to be done the use of steam ditchers is recommended, together with the use of at least two 16 to 20 yd. side-dump cars and a spreader car for short hauls. For a longer haul from 4 to 6 side-dumps should be used. A light locomotive can be assigned to handle this outfit, and with an outfit of this kind, which includes a train crew, ditcher engineer and fireman, dirt can be handled for 10 ct. to 25 ct. per yard, according to the length of haul.

Through long usage the steam ditcher and spreader, especially when the latter is operated by air, has reached such a high state of efficiency that they are practically indispensable, and the fact that they can be used for many different varieties of work places them among the most important labor-saving devices.

A saving of at least 60 per cent over that of manual labor is obtained by using a No. 3 crane for removing ballast from between tracks, in preparing for stone ballast, digging drains under tracks, unloading old ballast on fills, to strengthen shoulder and fill up holes, load and unload rails, and for various other purposes.

The magnet is used very successfully to load and unload scrap of various kinds. This machine is capable of picking up six or eight 33-ft. rails as rapidly as it will one, and eliminates handling the rails by hand, and reduces to a minimum the liability of injuring men

Two-wheel Pony Cars in Rail Laying.—In rail laying the pony car is very handy for distributing spikes, bolts, angle bars, tie plates, and even scattered rails. Where a heavy rail is to be replaced in track by a small gang a pony car makes it possible to load rail and move it to point where needed, without sending for additional help or using a flag to get rail to place; also useful handling ties. These cars with a dump box are very handy for distributing the surplus of gravel or stone ballast. Boxes hold ⅓ to ½ yd. and can be handled without flag by dumping. They can be dumped inside or outside the rail.

Ballast Plough.—All ballast may be removed by bolting a steel plate on to the present type of plough and permitting the plate to reach the entire length of the tie, only removing enough of the plate to clear rail and joint fastenings, the depth of plate depending on height of rail in track from which ballast is to be removed. An attachment to do this work can be made and applied by a blacksmith and helper in two days, and material needed may consist of scrap bridge iron or angle bars, and is a very inexpensive attachment and of great value for removing ballast that has been unloaded for backfilling. Removing and dressing ballast by hand is hard work and very expensive under ordinary conditions, and at present, when sufficient labor is unavailable, this device is of immeasurable value where much ballasting is in progress. In addition to this attachment, another plate with teeth may be applied to loosen up and level off ballast between parallel tracks and on shoulder. It will also destroy weeds. It can be operated at a speed of from 4 to 6 miles an hour. The saving effected per mile will depend on the amount of ballast to be removed and the density of vegetation.

Push Car With Filled Dump Box.

Field Telephones.—It is recommended that the field telephone be furnished to ballast and rail-laying gangs, also on work trains and snow ploughs, particularly on lines with heavy traffic. These outfits can be purchased for from $5 to $25 a set, and will reduce to a minimum the delays to extra gangs and trains, and will result in a saving of money which cannot be closely estimated.

Other Devices.—There are many devices so universal in their use as to be practically a necessity for all roads, yet they have not been adopted. There should surely be no excuse for longer allowing a large force of men to dig ditches in a cut when the ditching machine has reached the stage of perfection it has. Neither should there be an excuse for a large force of men wasting time and energy when machines can be secured which will accomplish the work with more safety and economy.

Dump Box Being Emptied.

It has been truly said that no two railways are alike, and for their maintenance requirements it may be as truly stated that no two sections are identical. What will prove of the greatest advange on one road would be money uselessly expended on another. It is, therefore, impracticable for the committee to lay down hard and fast rules for the adoption of certain devices under all conditions. It is, however, most earnestly convinced that the adjustment of little details very often means the ultimate success or failure of a machine or device.

1920 Census Will Present Statistics of Manufactures by Industrial Zones.—The Federal census of manufactures and mines and quarries is now under way and by March 1 a large field force will be engaged in collecting these statistics. A special feature of this census will be the presenting of the statistics of manufactures by industrial zones. In former census years statistics of manufactures have been presented geographically by states and by cities of 10,000 population and over, with a supplemental exhibit for from twelve to fifteen metropolitan districts. The general trend shown by large industrial enterprises seeking suburban locations, where the necessary space and adequate switching facilities may be secured at reasonable cost and without taxation at city rates, has created a new condition. To reflect this industrial expansion the Census Bureau at the current census will show as a third geographical unit, the industrial zone. The 69 largest manufacturing localities, those embracing a population of 100,000 and over, or practically those manufacturing sections representing $100,000,000 of manufactured products have been selected for a special presentation as "industrial zones."

Grain Pressures in Storage Bins.—To facilitate the designing of grain bins by engineers, tables of pressures, graphical charts, and rules for the more advantageous application of pressure tables, are included in a publication just issued by the Bureau of Markets, United States Department of Agriculture. Engineers may obtain copies of the very limited edition upon application to the Division of Publications, United States Department of Agriculture, Washington, D. C., for Bulletin 789, "Notes on Grain Pressures in Storage Bins." A bibliography on the subject of pressure of stored grain is included in the bulletin.

Rail Wear on Electric Railways

Mr. R. C. Cram, Engineer Surface Roadway, Brooklyn Rapid Transit Co., writing in the Electric Railway Journal, has made a praiseworthy attempt to assemble and comment upon the available data from different sources on this, a subject about which much more information is needed. The matter is of increasing importance because of the many appraisals and valuations now being made. The following is taken from Mr. Cram's article:

Rail wear is a shortened term for loss of section which may be caused by many different agencies. A number of these do not act upon rails in private right-of-way, while they greatly assist wear upon rails in streets. In short, location has a very distinct influence upon the kind and rate of wear. That upon rails in private right-of-way is almost wholly due to abrasion from car traffic, while in streets wear is also produced by vehicular traffic, corrosion, use of sand and corrugation. The last-named, since it requires grinding, causes a serious loss of section which must be classed as wear.

The difference in level of ¼ to ½ in. between the inner and outer rails found in tracks on some roads, where an attempt is made to conform the tracks to the crown of the street, will produce an excessive wear in the lower rail.

That vehicular traffic plays a big part in the wear of rails is seldom realized. Measurements taken in Chicago by the Board of Supervising Engineers, Chicago Traction, showed that rails which had never had a car over them but were subjected to heavy vehicular traffic were worn on the head to the extent of 5 per cent of their total wearing value in a period of 40 months. On lines carrying a car traffic of 40 cars per 20-hour day the vehicular wear may be one-half of the total wear, thus reducing the rail life of the 129-lb. groove girder rail by that amount. On a short section of track with heavy car traffic but with no vehicular traffic, the rate of wear was no greater than upon a line having only one-half the car traffic but with heavy vehicular traffic.

There is no question as to the influence of car wheels and their condition upon rail wear. Wheels which are allowed to exceed their proper wear and contour limits cause uneven bearing upon rail heads, localizing the loads, and causing extrusion of metal and side cutting of grooves. Excessively sharp or deep flanges are trouble makers. Wheels improperly paired or "out of round" contribute their share, and it is well known that flat wheels are provocative of damage in several directions. Improper mounting upon axles will cause excessive side wear of heads and grooves.

The use of sand in bad weather, while it aids traction, also increases rail wear; it would hardly be effective otherwise. That sand helps to wear rails is proven by the results where on some roads it is used on the inner rail only. This rail almost invariably shows the greater wear. W. C. Willard, in his book "Maintenance of Way and Structures," states that in steam road service the use of sand about doubles the wear under a given traffic.

The general alignment of tracks with respect to curvature also has a marked influence upon rail wear. It is only necessary to point out that sharp curves will wear out in from 3 to 6 years, while adjacent tangent tracks will last for 15 years under the same service.

The use of special alloy-steels has been tried by both steam and electric railways as a means of securing greater life for rails in curves with varying results but the consensus of opinion seems to be that their use is not generally warranted for ordinary street service when cost differences are taken into account. In certain special cases, as in subways, on elevated roads or in other locations where the radius of the curves is very short and where the renewal work is difficult and of very high cost, some allow steels may be warranted. In general a special alloy steel can only be justified on a cost basis, when the life of the alloy steel is three or more times that of ordinary open-hearth steel. An instance of justified use of manganese steel in such conditions was that of the first rail of this kind installed in the Boston subway near the Park St. Station in 1902, where an 82-ft. radius curve of ordinary Bessemer rail steel lasted only 44 days. Manganese was substituted and lasted over 6 years, or over 52 times as long.

An instance of unjustified use of manganese in surface track curves is at the Brooklyn end of the Brooklyn Bridge. Here a manganese curve of about 150-ft. radius lasted 4 years. It cost over $1,300. A similar curve of ordinary open-hearth girder rail installed as a renewal of the manganese curve and costing only $460 lasted 5 years, and in renewing this curve in 1919 a heavier guard rail was used which will undoubtedly last at least 7 years.

Corrosion causes a loss of section which is usually classed under the head of wear. It is not very prevalent on steam roads, where it is caused mainly by brine drippings. In electric railway service in streets, corrosion may be caused by soils, proximity to salt water, lack of good bonding and even lack of good under drainage. The U. S. Bureau of Standards has made important tests which indicate that ballast conditions have a marked influence upon the form of corrosion known as electrolysis.

We are all more or less familiar with the peculiar form of wear known as corrugation. The greatest loss of metal due to this is caused by grinding the rails to remove the corrugated metal. That the trouble is both serious and costly may be appreciated. The Brooklyn Rapid Transit System expends about $16,000 annually for the removal of corrugation and would have to spend more if an attempt was made to remove all traces of it and keep it down as fast as it appears. To date no adequate remedy or preventive has been found for this trouble, and a special attempt should be made to determine its cause. Once determined the remedy should be an easy matter.

In certain situations, such as upon elevated roads or in subways, the provision for safety no doubt warrants the assumption and use of an arbitrary wear life or head reduction limit, based upon some percentage of the total head area. This is done on the Boston Elevated Ry., where 85-lb. A. S. C. E. rails are arbitrarily renewed when 35 to 50 per cent of the head area has disappeared. It would be interesting to know just what tonnage or wheelage produces this wear. Meanwhile, the curved rail wear of open-hearth rails on the Chicago Elevated Rys., previously mentioned, showed a reduction of head area of 38 per cent for rails of 80-lb. A. S C. E. section at the time of maximum wear or removal.

It is somewhat difficult to set what may be termed the total or available head area It will vary with each rail section and a maximum percentage of reduction which may be safe for tracks in pavements might be unsafe for open tracks. It will also depend upon the manner in which the rail is worn, since the wear produced in curves is considerably different in contour and position from that found in straight track

The area reduced by wear was found by the Lorain Steel Co. to vary from 11 to 69 per cent of the total head area in rails removed from streets in 40 different locations and covering each of the three types of girder rail now in use. The ages varied from 14 to 21 years. The average reduction was 32.98 per cent of the total head area.

Two important details of design have had a large influence upon rail wear. These are the flat or plane head and the position of the gage line with respect to the center line of the web Recent designs have increased the distance of the gage line from the center of the web so that the wheel load may be more nearly central over the web, thus reducing distortion of the head due to eccentric load. The plane head has been changed to a curved one with beneficial results, in that the extrusion of metal at the gage line fillet with consequent loss of metal has been eliminated and a much wider range of contact between wheel and rail has been secured, thus decreasing wear from concentration of load. The curved head design has not prevented corrugation, although it has greatly delayed the time of its first appearance. Where corrugation would appear in five days on plane head rails, it takes two or more years for it to appear on curved head rails.

To sum up, the wear of electric railway rails in streets is dependent upon operating speed, weight of equipment, density of car traffic, amount of vehicular traffic, use of brakes, frequency of stops, grades encountered, general alignment with respect to curvature, design of rails, design of wheels, upkeep of wheels, use of sand, cleanliness of streets, and manufacture and composition of rails. Of the foregoing, it is apparent that most of the items are so variable that only those of rail design, wheel design, composition and maintenance are subject to reasonable control.

Rapid Method of Applying Prismoidal Correction in Computing Earthwork Volumes

What is believed to be a new method of employing prismoidal corrections in calculating earthwork quantities is described by J. Grant MacGregor in a recent issue of the Journal of the Engineering Institute of Canada, from which the matter following is taken.

The usual method of computing earthwork is by taking the quantities from a table giving cubic yards for the sum of the end areas, and basing the correction for the prismoidal formula on the difference in width and depth of the two cross sections, representing the form of the prismoid. In order that the prismoidal correction can be applied in this manner, there must also be a similarity of form between the cross sections.

To compute earthwork accurately the cross sections must at least represent the average contour of the ground lying between them, and it is sometimes difficult to do this by what is known as a 3 or 5-level cross section in order that the prismoidal formula may apply.

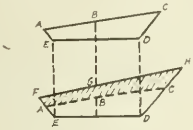

Fig. 1.

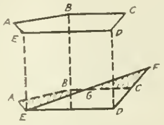

Fig. 2.

It may not have occurred to many engineers that the prismoidal correction may be based, not only on the general dimensions and form of the prismoids, but also on the ratio which the two end areas bear to one another. The assumption is that a prismoid of unequal end areas is composed of a number of small prismoids, the unit being a square foot at the base for the larger area, and terminating at the smaller end with an area proportional to the area of the smaller cross section. By dividing the larger area of one cross section by the smaller area of the other this ratio is obtained that is applied in the following table, giving the prismoidal correction for a prismoid 100 ft. long and 100 sq. ft. at the base:

Ratio of end areas.	Prismoidal correction base 100 sq. ft.	.1	.2	.3	.4	.5	.6	.7	.8	.9
1-1	.00	0.05	0.21	0.47	0.55	1.33	1.91	2.61	4.26	4.31
1-2	5.33	0.06	0.23	0.53	0.90	1.49	2.14	2.92	3.81	4.82
1-3	11.29	0.04	0.15	0.37	0.66	1.03	1.49	2.03	2.65	3.36
1-4	15.44	0.03	0.13	0.30	0.54	0.85	1.23	1.68	2.19	2.78
1-5	18.87	0.02	0.11	0.25	0.44	0.69	1.00	1 37	1.78	2.26
1-6	21.66	0.02	0.08	0.18	0.33	0.51	0.73	1.00	1.31	1.66
1-7	23.73	0.02	0.03	0.20	0 34	0.53	0.77	1.05	1.37	1.74
1-8	25.88	0.01	0.06	0.15	0.27	0.42	0.60	0.82	1.08	1.38
1-9	27.57	0.01	0.05	0.11	0.20	0.31	0.45	0 62	0.81	1.03
1-10	28.84	....	....	....	....	....	....	....	....	....

The same result is obtained by computing the volume of a prismoid of uniform cross section corresponding to the smaller cross section and adding to this the remaining wedge having an area at the base equal to the difference of the areas of the two cross sections.

The assumption in the case of a wedge is the same as for a prismoid, i. e., the mass would be composed of a number of small wedges having a base area of one square foot and vanishing at the upper perimeter of the smaller cross section. It is evident, therefore, that if the volume of the prismoid requires no correction, being uniform throughout, the remaining wedge is responsible for the entire correction to be made. In this way the table is made applicable to wedges as well as prismoids, the ratio for the correction in the case of a wedge, being the square root of the length of the thin edge for 100 sq. ft. of base, or in the above case the square root of the width at the upper perimeter of the smaller cross section.

The foregoing appears to be true regardless of the dissimilarity of the cross sections and will apply in a case where the usual prismoid terminates in a triangle with a warped surface, providing that straight lines drawn from any point on the upper perimeter of one cross section to a corresponding point on the other will coincide with the warped surface of the prismoid. In the case of the prismoid terminating in a triangle as in Fig. 2, two wedges are formed, one being positive and the other negative. The vanishing point as before being at the upper perimeter of the cross section A. B. C. D. E.

The same table of quantities for the sum of the end areas may also be used for the correction to be applied. It was found that if the smaller end area was computed throughout as a uniform prismoid requiring no correction the error was confined to the remaining wedge. It may also be shown in the figure that the correction required may be confined to the four quarter pyramids at the corners of the prismoid. The remaining four wedges along with the uniform prismoid contained within the four wedges, are applicable to the table without any correction for the prismoidal formulas. The four quarter pyramids at the corners form a perfect pyramid, and in taking the quantity from the table of end areas corresponding to the base of the pyramid an error equal to one-third the true volume of the pyramid is made. This error is equal to the difference of the square roots of the end areas squared and divided by three, and is applied to the table as a negative quantity. The square roots of the end areas are readily obtainable from any table of squares and square roots and the operation is simpler and takes less time than by taking the correction from the table.

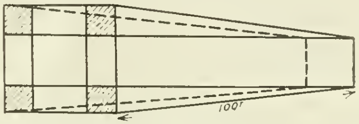

Fig. 3.

End areas, a, a′ in square feet.

Prismoidal correction:

$$(\sqrt{a}-\sqrt{a'})^2 \times \frac{100}{81} = \text{cu. yd}$$

Long Life Creosoted Piles

An instance of excellent service obtained from creosoted piles is described in a recent issue of Railway Age. A pile trestle approach to the Louisville & Nashville Ry. Ohio River bridge at Henderson, Ky., constructed in 1884, had 177 bents of creosoted piles. It became necessary to rebuild the trestle recently as about 15 per cent of the piles were seen to be in a condition calling for early removal, and furthermore the original four-pile bents were affording too small a factor of safety and especially as the panel lengths of the trestle were 15 ft. The piles taken out had therefore a service life of 35 years.

Only about 10 per cent of the piles requiring renewal showed serious rot at the ground line. The most serious cause of decay arose from a practice pursued when the bracing timbers were renewed in 1896. In a misguided effort to get good bearing for the braces, many of the old piles were adzed deeply, exposing the less heavily treated material. Some decay also started around bolt holes, although the holes for fastening the original bracing were, for the most part, carefully plugged at the time that the bracing was changed. The characteristic rot at these places consists of a small opening leading into a cavity of appreciable size in the interior.

An interesting comparison is afforded in this structure by the fact that all of the trestle that was not constructed of the creosoted piles was driven with red cedar piles that gave a life of about 18 years. All renewals of these cedar piles were made with untreated pine piles that have since been renewed at least once, so that the creosoted piles have given more than twice the life of the untreated wood. The long life secured from these piles is clearly the results of the use of good timber, correct treatment and a careful regard for the detailed precautions necessary to insure a continuity of the shell of protected timber on the exterior of the pile. Eventually decay, where it occurred, was in most cases the result of a failure to secure absolute perfection in this regard. It is entirely clear that the small percentage of piles requiring renewal at the present time would be even smaller than it is but for the unfortunate cutting of the piles at the time that the braces were renewed.

Modified Cost Plus Contract for City Use

A competitive cost-plus contract intended for the use of a city or state has been prepared by E. S. Dorr, Office Engineer of the Sewer Department of Boston, Mass. The following explanation of some of the provisions in the proposed contract is given by Mr. Dorr:

The difficulty in formulating a competitive cost-plus contract is in establishing a real and controlling relation between the bid and the payments for the work, which will also be fair to both parties. Competitive cost-plus contracts have been made in which the contractor was required to state his estimate of cost, and received in payment the actual cost of the work, plus a fee, and plus a bonus or minus a penalty, according to whether he had made the actual cost less or more than his estimate. This would work all right, provided the actual quantities correspond to the estimated quantities, but if they do not, the result is complicated. For instance, the actual cost might exceed the estimate due wholly to an excess of the actual over the estimated quantities, when at the same time the actual item cost had been made, through efficiency in the management, less than the estimated item cost.

By the provision for an itemized bid, and the provision for a "modified estimate," a complete means of correction is supplied. The modified estimate is the estimate which the contractor would have made in his proposal, had it been possible for him to have known beforehand just what the actual quantities would be. Bonuses and penalties are then figured upon the basis of the modified estimate, and not the original estimate, which is just.

The reasons for making the fee a percentage of the estimate, for making it as high as 15 per cent and for fixing the percentage instead of having it bid, are as follows:

If the fee were made a lump sum, this sum would have to bear a percentile relation to the estimated cost; it is simpler to make it a percentage.

The size of the fee compared to the estimate makes but little difference to the contractor in making his bid; he is then making up a sum, called the "arbitrary sum," which is to be used in comparison of bids, and will try to keep it low, so as to secure the contract. If he concludes to reduce this sum, he would naturally do it by cutting down on the fee; he would keep the estimate high and the fee low, because a high estimate increases the chance for a bonus, and because the fee is the fund from which penalties are taken, and as soon as it is exhausted, he escapes control in a large measure. As the contract is framed, his only way of reducing the arbitrary sum is by reducing the estimate (and time); which reduces the amount although not the percentage of the fee. If the fee is reduced unduly in this manner the contractor has no grounds for complaint.

It should be observed that the modification of the fee is to be for precisely the same reason and in the same proportion as that of the estimate; it is a purely corrective measure. It is based upon changes in quantities only, and is not affected by efficiency or the lack of it.

The provision for bonuses and penalties covers the features of efficiency. The bonus of 75 per cent of the saving on the modified estimate may appear to be large, but is essentially just, for if a contractor can save anything on an estimate made in competition he is entitled to the largest share of it. But there is another practical reason for making the bonus large. The weakness of a percentile contract is in the opportunity it offers for fraud by padding pay-rolls and double billing of materials; a large bonus minimizes this evil; it would not pay a contractor to risk his reputation for what little there would be in it for him.

The aim has been to devise a form of percentile contract which would attract able and reputable contractors, and would induce and compel each one to bid just about what he thought he, with his resources, could do, and then make good on it and better it if he could.

The following is an outline of Mr. Dorr's proposed competitive cost-plus contract:

Proposal.—(a) The city shall furnish a list of the items of the work substantially as in the present form of contract, including estimates of quantities of all kinds of lumber which it is intended to incorporate in the work or leave in, and including an itemized statement of the quantities of materials which the city will furnish with values of such materials. The contractor shall bid prices on all other items.

It is to be understood that the quantities stated in the proposal are assumed solely for the purposes hereinafter described in paragraphs (b), (d), (e), (f), (g), (i) and (j). The commissioner does not expressly or by implication agree that the actual amount of work will even approximately correspond therewith, but reserves the right to increase or diminish the amount of any class or portion of the work as he may deem necessary.

If the price of any item bid by the contractor, or the sum total of all the items, is obviously abnormally high or low, the commissioner reserves the right to reject the proposal.

If required so to do, the contractor shall furnish evidence satisfactory to the commissioner that he has ability and experience in this kind of work, and that he has sufficient capital and plant to enable him to prosecute the same successfully, and complete it within the time hereinafter stated by him; and the commissioner reserves the right to reject any or all proposals or to accept any proposal, should he deem it for the interest of the city so to do.

(3) The city shall compute, as a lump sum, the contractor's estimate of the total cost of the work, exclusive of his fee. This lump sum shall be made up by adding together the values of the items of the work (including the materials to be furnished by the city), reckoned at the prices stated by the city for materials furnished by it, and at the prices bid by the contractor for materials and labor furnished by him, in the proposal.

(c) The contractor shall state, in number of working days, the time required by him for the completion of the work.

(d) The contractor shall receive, as a lump sum, a fee as full compensation for his personal services and that of his organization, including profit and all general overhead expenses, except as hereinafter otherwise provided. The fee shall be 15 per cent of the contractor's estimate (unmodified), including the value of the materials to be furnished by the city. This sum shall be used as the fee for comparison of bids only; it may be modified for payment as hereinafter described.

Comparison of Bids.—(e) Bids will be compared on the basis of an arbitrary sum to be computed by adding together the three following sums:

1. The lump sum reckoned as above stated as the contractor's estimate of the cost of the work;

2. A sum obtained by calculating 1 per cent per month (thirty days), or 1/30 of 1 per cent per day of the "estimate" for the "time" stated by the contractor as required by him for the completion of the work;

3. The lump sum to be received by the contractor as his fee.

(f) This arbitrary sum will be calculated in the manner described above, from the bid of each contractor for the purpose of comparison of bids only, and the smallest sum so obtained shall be considered the lowest bid.

Modification of the Estimate.—(g) If the quantity in any item of work shall be found to exceed by more than 10 per cent the amount of such work estimated and stated (as above), the estimate shall be increased, for the purpose of calculating bonuses and penalties (to be hereinafter described), by the amount of the cost to the contractor of such excess, reckoned at the item prices as stated in the proposal.

And if the quantity of any item of the work shall be found to be less by more than 10 per cent than the amount estimated and stated (as above) the estimate shall be decreased for the same purpose and in the same manner as above described for an increase.

If the Commissioner of Public Works shall order the contractor to perform "extra work," the contractor shall do such work to the satisfaction of the commissioner and in such manner as he shall direct, and the estimate shall be increased by the cost of such work as determined by the commissioner from the force accounts.

Modification of the Time.—(h) If the estimate shall be increased or decreased for the reason stated, the time shall be correspondingly increased or decreased by the same percentage in days that the increase or decrease in money bears to the original estimate, and for the same purpose. The time may be increased (in addition) by the Commissioner of Public Works of the city on account of inclement weather, or by delays caused by the city, or otherwise, for which the contractor is in no wise responsible.

Modification of the Fee.—(i) If any increase or decrease shall be made in the quantities, a corresponding increase or decrease shall be made in the fee, that is, the fee shall be increased or decreased by the same percentage of the fee that the increase or decrease in the cost of such quantities, reckoned as stated in the proposal, bears to the original estimate. Moreover, if an increase shall be made in the estimate on account of "extra work," a corresponding percentile increase shall be made in the fee, as in the case of an increase in the quantities.

The fee shall be increased by bonuses and decreased by penalties on economy in the cost and in the time of completion of the work as hereinafter described.

Bonus and Penalty for Economy in Cost.—(j) If the total cost of the work (exclusive of the fee) shall fall below the contractor's estimate, modified as above described, (g), he shall receive a bonus of 75 per cent of the difference; and if the cost shall exceed such estimate the contractor shall suffer a penalty of 50 per cent of the difference, such bonus of penalty being added to or subtracted from the modified fee (i).

Bonus and Penalty for Economy in Time.—(k) If the total time occupied by the contractor in doing the work, modified as above described, shall fall below the time estimated by him in his proposal, he shall receive a bonus of 3 per cent per month (thirty days), 1/10 of 1 per cent per day, of the estimate modified as above described, for the difference in time between the time estimated and the time used; and if the time used shall exceed the time estimated, he shall suffer a corresponding penalty calculated in the same manner, such bonus or penalty being added to or subtracted from the modified fee (i).

Payments.—(l) Payments for labor and materials shall be made monthly, for labor as shown by the payrolls checked by the force accounts, and for materials as shown by receiped vouchers.

There shall be no partial payments on account of the contractor's fee.

The fee, modified as above described, shall be paid to the contractor upon the completion and acceptance of the work.

Approval of Cost of Materials.—(m) The contractor, before purchasing any material, shall submit to the commissioner a statement of the quantity and price of the material he intends to buy, and shall purchase only upon the commissioner's approval of quantity and price.

(n) The city may furnish, at any time, any materials other than those stated in the proposal; the cost of materials purchased by the city for said work, exclusive of all freight charges thereon, shall be included in the cost of the work for the purpose of reckoning the fee to the contractor and the modified estimate, but for no other purpose.

Locating Submerged Trees by Wire Drag

An important adaptation of the wire drag has been employed by a party of the U. S. Coast and Geodetic Survey in locating submerged trees in Lake Washington. The trees are found with the drag, and are then dragged up or their tops blown off by the U. S. engineers' snagboat Swinomish. Many of the trunks are from 60 to 100 ft. in height, and as they reach in some instances to within a few feet of the surface, they constitute very dangerous obstructions to navigation. The depth of water surrounding them is great; they occur often at a considerable distance from the shore, and there is no surface indication of them whatever.

Owing to the existence of these trees the drag can not operate except at the risk of damage and loss of equipment. On the other hand the Government snagboat has no means of locating the trees without the use of the drag. The two operations are, therefore, mutually interdependent and are carried on almost simultaneously.

As soon as a tree is caught by the drag the army engineers take charge. They get a cable around the tree and then either pull it up or blow the top off with dynamite. As soon as they have cleared out the trees that have been found by the drag, and incidentally recovered such parts of the drag as they are able to save, the same region is again dragged over to see if all the trees have been found.

When the drag catches on submerged trees it is at once badly tangled up, and it is evident that in a short time, without the aid of the snagboat, all of the available drag equipment would be tangled up in trees, as it is quite impossible to remove the drag from the trees by any means at the disposal of the drag party.

The essential point of the whole operation is this: The drag party is well equipped to find the trees, and methods have been developed to locate individual needle-point trees on which the drag does not catch hard. On the other hand the snagboat is not equipped for sweeping. They actually sweep to get their cable around the tree, but as the cable is heavy and they do not wish to catch the tree below a certain depth, only the lowest part of the cable hight is at such a depth as to catch the tree. Their effective sweep is then only 10 to 15 ft. long at full depth, and this length can not be increased without catching trees far below the depth desired.

In the wire-drag work the boats have been used in the following combinations: Scandinavia and motor sailor; Scandinavia and Helianthus; Helianthus and motor sailor; two dinghies with 50-ft. sweep of two lead lines with leads connected by marline (six trees have been located in a day using this method alone); and the use of a dinghy with lead-line trailing (by which method four trees have been found).

Motor Trucks in Railway Maintenance Work

The Pennsylvania R. R. recently placed in service two motor trucks for the express purpose of relieving work train service. The trucks are operated in busy main line territory where the public roads give access to the railroad at frequent points. Each truck is under the jurisdiction of a supervisor, one being located at Paoli, Penn., and the other at Newport. The trucks are used for delivering small track materials, coal to stations and towers, hauling ashes and other refuse, the maintenance of station grounds and numerous other items of work, which heretofore had involved the hiring of teams or trucks. The following particulars regarding the operating results from these motor trucks are taken from the January Railway Maintenance Engineer.

The truck at Newport has been in service approximately five months and in that time has entirely replaced an extra work train, which was formerly used about one day a week. It has, as well, obviated the necessity and the expense of hiring teams. Since this truck was purchased it has covered approximately 3,000 miles and has used on the average 4½ gal. of gasoline per day. It has been working daily, except Sunday, 8 hours per day, and up to the present time there has been no expense for repairs.

The following is a comparative statement of the cost of work train and hired teams as against the cost of doing the same work by motor truck:

ANNUAL OPERATING EXPENSES OF TRUCK.

Interest on investment	$ 288.84
Depreciation at 20 per cent	962.75
Gasoline	337.75
Oil	45.00
Wages of driver and helpers	2,663.00
Tires and repairs (estimated)	400.00
License	25.00
Total	$4,722.34

ANNUAL COST OF CORRESPONDING WORK TRAIN AND HIRED TEAMS.

Work train, 56 days—	
Labor	$3,655.68
Work train expenses and crew	3,188.64
Hired teams	753.40
Total	$7,597.72
Annual saving	2,875.38

Prior to January, 1919, the delivery of coal and the removal of ashes from stations, watch boxes and towers on sub-division No. 2, Paoli, was made by work trains, as was also the delivery of supplies for the upkeep of stations, sidings and bridges. In other words, the materials required by the master carpenter, such as cement, sand, gravel, lumber, nails, etc., were transported by work trains. During 1918 the condition of the track demanded more service from the work trains and the question of relieving them from the above-mentioned work by the use of a truck was considered.

The following is a summary of the cost of the work done by the work train and the work done by this truck:

ANNUAL OPERATING EXPENSES OF TRUCK.

Interest on investment	$ 164.40
Depreciation at 20 per cent	548.00
Gasoline	425.00
Oil	85.00
Wages of driver and helpers	4,180.00
Expenses, repairs, etc	235.00
License	15.00
Total	$5,652.40

COST OF CORRESPONDING WORK TRAIN SERVICE.

Cost of delivering coal	$4,497.60
Hired teams	233.25
Handling ashes	1,170.00
Work train for mason's and carpenter's supplies	2,400.00
Total	$8,300.85
Annual saving	2,648.45

Because of the good roads in this section a truck was able to reach all the points on the sub-division except two towers. In January, 1919, a 2-ton truck was purchased and placed in service. This truck has now been in service 10 months, working 10 hours a day for 8 months and 16 hours a day for two months. It has relieved the work train of all the work named above and has also been able to expedite the delivery of repair parts necessary on the subdivision. During the 10 months this car has been in service the bills for repairs have totaled but $20, while an average of 5 gal. of gasoline and 1 qt. of oil have been used per day.

Rental Rates for Grading Contractors Equipment

A useful table giving rental rates for grading equipment has been compiled by Mr. F. J. Herlihy, of Minneapolis, Minn. The table, which is reprinted below, shows the original capital cost of his equipment, depreciation charges, average earning days per year, daily charge for interest, depreciation, insurance and storage, and total daily rental charge:

Class of equipment.	Original capital cost.	Equivalent annual interest rate on **original** cost. Per cent.	Annual rate of depreciation on original cost. Per cent.	Annual insurance and storage rate on original cost. Per cent.	Total annual rate of accrued charges on original cost. Per cent.	Total annual charge.	Average earning days per year.	Daily charge for int., dep., ins. and storage.	General shop repairs daily.	Daily rental.	Est. cost field repairs daily.	Total rental charge daily, incl. field repairs.
Steam shovel	$12,000	3¾	12½	3¾	20	$2,400.00	200	$12.00	$ 4.00	$16.00	$ 4.00	$20.00
Steam shovel	20,000	3¾	12½	3¾	20	4,000.00	200	20.00	6.00	26.00	6.00	32.00
Steam shovel	30,000	3¾	12½	3¾	20	6,000.00	200	30.00	9.00	39.00	9.00	48.00
Steam shovel	90,000	3¾	12½	3¾	20	18,000.00	200	90.00	25.00	115.00	25.00	140.00
Drag line excavator	20,000	3¾	12½	3¾	20	4,000.00	200	20.00	10.00	30.00	10.00	40.00
Drag line excavator	30,000	3¾	12½	3¾	20	6,000.00	200	30.00	15.00	45.00	15.00	60.00
Standard gage locomotive	12,000	3¾	12½	3¾	20	2,400.00	200	12.00	5.00	17.00	5.00	22.00
Standard gage locomotive	16,000	3¾	7½	3¾	15	2,400.00	200	12.00	6.00	18.00	6.00	24.00
Standard gage locomotive	24,000	3¾	7½	3¾	15	3,600.00	200	18.00	8.00	26.00	8.00	34.00
Dinkey locomotive	4,000	3¾	12½	3¾	20	800.00	200	4.00	1.50	5.50	1.50	7.00
Dinkey locomotive	6,000	3¾	12½	3¾	20	1,200.00	200	6.00	2.50	8.50	2.50	11.00
Locomotive crane	20,000	3¾	12½	3¾	20	4,000.00	200	20.00	6.00	26.00	6.00	32.00
Jordan spreader	9,000	3¾	12½	3¾	20	1,800.00	200	9.00	3.00	12.00	1.00	13.00
Rail, per ton	48	3¾	7½	3¾	15	7.20	200	.04	.01	.05	.00	.05
Track throwing machine	6,000	3¾	12½	3¾	20	1,200.00	200	6.00	2.00	8.00	1.00	9.00
20-yard air dump cars	3,750	3¾	12½	3¾	20	750.00	200	3.75	.25	4.00	.25	4.25
16-yard air dump cars	2,800	3¾	12½	3¾	20	560.00	200	2.80	.20	3.00	.25	3.25
12-yard air dump cars	2,000	3¾	12½	3¾	20	400.00	200	2.00	.15	2.15	.15	2.30
4-yard dump cars	430	3¾	12½	3¾	20	86.00	200	.43	.07	.50	.10	.60
1½-yard dump cars	110	3¾	12½	3¾	20	22.00	200	.11	.09	.20	.10	.30
1-yard dump cars	90	3¾	12½	3¾	20	18.00	200	.09	.06	.15	.10	.25
Flat cars	1,000	3¾	7½	3¾	15	150.00	200	.75	.15	.90	.10	1.00
Gasoline locomotive	3,200	3¾	12½	3¾	20	640.00	200	3.20	1.05	4.25	1.25	5.50
1-yard Koppel cars, V-shape	110	3¾	12½	3¾	20	22.00	200	.11	.04	.15	.05	.20
Motor truck, 5-ton	6,000	3¾	22½	3¾	30	1,800.00	200	9.00	7.50	16.50	5.00	21.50
Automobile	2,000	3¾	31¼	15	50	1,000.00	200	5.00	2.50	7.50	2.50	10.00
Caterpillar tractor, gas	5,000	3¾	12½	3¾	20	1,000.00	150	6.66	8.34	15.00	5.00	20.00
Vertical boiler	900	3¾	7½	3¾	15	135.00	100	1.35	.65	7.00	.00	7.00
Locomotive boiler	1,500	3¾	7½	3¾	15	225.00	100	2.25	1.00	3.25	.00	3.25
Steam pump	500	3¾	7½	3¾	15	75.00	100	.75	.50	1.25	.00	1.25
Centrifugal pump, D. C.	1,500	3¾	7½	3¾	15	225.00	100	2.25	1.25	3.50	.50	4.00
Belted pump	300	3¾	7½	3¾	15	45.00	100	.45	.30	.75	.00	.75
Deep well pump	600	3¾	7½	3¾	15	90.00	100	.90	.60	1.50	.00	1.50
Gasoline engine	1,200	3¾	7½	3¾	15	180.00	100	1.80	.60	2.40	.10	2.50
Steam engine	1,800	3¾	7½	3¾	15	270.60	100	2.70	.90	3.60	.15	3.75
Hoisting engine	4,250	3¾	7½	3¾	15	637.50	100	6.38	2.12	8.50	.50	9.00
Horse pile driver	800	3¾	12½	3¾	20	160.00	100	1.60	.40	2.00	.00	2.00
Steam pile driver	2,000	3¾	12½	3¾	20	400.00	100	4.00	.75	4.75	.75	5.50
Track pile driver	10,000	3¾	7½	3¾	15	1,500.00	100	15.00	3.00	18.00	2.00	20.00
Steam pile hammer	2,500	3¾	7½	3¾	15	375.00	100	3.75	.75	4.50	.50	5.00
Air compressor	3,000	3¾	7½	3¾	15	450.00	100	4.50	1.50	6.00	.50	6.50
Electric motor	500	3¾	12½	3¾	20	100.00	100	1.00	.35	1.35	.15	1.50
Deep well drill	2,000	3¾	12½	3¾	20	400.00	100	4.00	.50	4.50	.50	5.00
Steam tripod drill	400	3¾	12½	3¾	20	80.00	100	.80	.20	1.00	.25	1.25
Jackhamer drill	140	3¾	12½	3¾	20	28.00	100	.28	.22	.50	.25	.75
Air steel sharpener	2,000	3¾	12½	3¾	20	400.00	100	4.00	.25	4.25	.25	4.50
Stiff leg derrick	2,000	3¾	12½	3¾	20	400.00	100	4.00	.50	4.50	.75	5.25
Forrest log loader	400	3¾	12½	3¾	20	80.00	100	.80	.20	1.00	.25	1.25
Lee wagon loader	225	3¾	12½	3¾	20	45.00	100	.45	.15	.60	.15	.75
Clamshell bucket	1,500	3¾	12½	3¾	20	300.00	100	3.00	.25	3.25	.25	3.50
Rock channeler machine	3,000	3¾	12½	3¾	20	600.00	100	6.00	2.00	8.00	1.00	9.00
Grading machine	1,350	3	23¼	3¾	30	405.00	150	2.70	1.30	4.00	1.00	5.00
Pony road grader	200	3	23¼	3¾	30	60.00	150	.40	.20	.60	.15	.75
Grading plow	30	3	23¼	3¾	30	9.00	150	.06	.04	.10	.00	.10
Dump wagon	180	3	23¼	3¾	30	54.00	150	.36	.34	.70	.15	.85
Hauling wagons	120	3	23¼	3¾	30	36.00	150	.24	.21	.45	.15	.60
Wheel scrapers	50	3	33¼	3¾	40	20.00	150	.13	.12	.25	.00	.25
Slip scrapers	8	3	43¼	3¾	50	4.00	150	.03	.02	.05	.00	.05
Fresno	22	3	43¼	3¾	50	11.00	150	.07	.08	.15	.00	.15
Switches, complete	150	3¾	7½	3¾	15	22.50	200	.11	.02	.13	.00	.13
2-in. galv. pipe, per 100 ft	22	3¾	7½	3¾	15	3.30	200	.02	.01	.03	.00	.03
2½-in. galv pipe, per 100 ft	34	3¾	7½	3¾	15	5.10	200	.03	.01	.04	.00	.04
3-in. galv. pipe, per 100 ft	45	3¾	7½	3¾	15	6.75	200	.04	.01	.05	.00	.05

Two New Base Maps of the United States

Two new base map projections of the United States have recently been brought out by the U. S. Coast and Geodetic Survey. They are called the Lambert Zenithal Equal Area Projection and the Lambert Conformal Conic Projection. From a circular issued by the survey the following facts are taken:

The Zenithal Projection is on a scale of 1 in 7,500,000 and has dimensions 19¾ in. by 25¾ in. Its price is 15 ct. The map covers the whole of the United States, including the northern part of Mexico. Only state names and boundaries, principal rivers, capitals and largest cities are shown, the chief object being to furnish a base map for political, census, or statistical purposes on a projection in which the property of equivalence of area is one of the essential features. The zenith of the central point of the surface to be represented appears as pole in the center of the map; the azimuth of any point within the surface, as seen from the central point, is the same as that for the corresponding points of the map; and from the same central point, in all directions, equal great circle distances to points on the earth are represented by equal linear distances on the map.

The Conformal Projection is on a scale of 1 in 5,000,000, dimensions 25 by 39 in. Price, 25 ct. Its advantages over other projections are as follows: 1. Conformity. 2. Straight meridians cutting all parallels at right angels. 3. Simplicity of construction and use. 4. Two selected standard parallels of latitude are of true scale. This map is of special interest from the fact that it is based on the same system of projection as that which was employed by the allied forces in the military operations in France. The value of this new outline map can best be realized when it is stated that throughout the larger and most important part of the United States, the maximum scale error is only one-half of one per cent.

A comparison of errors of scale and errors of area in a map of the United States on three different projections is as follows:

MAXIMUM SCALE ERROR

	Per cent.
Polyconic projection	6½
Lambert zenithal projection	1⅞
Lambert conformal projection	2⅓

MAXIMUM ERROR OF AREA.

Polyconic projection	6½
Lambert zenithal projection	0
Lambert conformal projection	5⅓

Advantages of the Fixed Price Contract

Much has been printed in the last few months on the advantages of the cost plus contract. In two recent contributions, however, men prominent in the contracting industry point out the advantages of the fixed sum contract. In the February Bulletin of the Associated General Contractors of America Mr. James O. Heyworth, Engineer and Contractor, Chicago, takes the position that the first mentioned form of contract robs the contractor of the opportunity of placing a premium on efficiency and ingenuity. Much the same view is taken by Mr. James W. Rollins of Holbrook, Cabot & Rollins, Boston, in a discussion appearing in the January Journal of the Boston Society of Civil Engineers. These articles are reprinted below:

Cost Plus Contracts and Fixed Price Contracts.

By James O. Heyworth.

Taking advantage of extraordinary conditions the last few years, much has been written, said and advertised by experienced and reliable authorities advocating the many advantages to employer and employe through cost plus fixed profit or percentage contracts in construction work.

The situation may be summarized as follows:

1st. There is no argument or question but that there is an advantage to the employe or contractor.

2nd. Speed in execution of work is seldom if ever obtained by executing a contract before plans and specifications are ready, although this is the argument commonly used with the layman.

3rd. The advantage to the employer is at best theoretical and is substantiated only by the talk of the salesman.

Why?

Because it robs the employer of the ingenuity of several minds and organizations in competition; it robs him of the opportunity to obtain a contractor who has an experienced and successful organization which needs work to hold together what has taken years to develop; it robs the contractor of the opportunity to place a premium on efficiency, ingenuity, long hours, sacrifice and success.

What contractor could intelligently bid on a job unless he had men in whom he placed confidence, at hand to put in charge of the job? It is an indefensible position for a firm to send one engineer or superintendent to a locality and start a job, employing all foremen and mechanics locally.

The cost plus a profit contract removes from a job the only standard by which success can be measured. By so removing this standard, it automatically kills the pride and satisfaction of the human being. What nation ever won a war with an army of hirelings? History has plenty of examples of such methods.

My experience has been that there is the highest type of loyalty, efficiency, sacrifice and citizenship in the men who really do the construction work of the country. They are as much interested in a job as is their boss, provided they have any real reason for this interest.

Ambition, satisfaction and contentment are never measured entirely and completely by the dollar.

Show me the man who at night comes into his home with the flush of success on his face; with the pride of achievement in his whole bearing; with the confidence and poise of contentment stamped on his brow; and I know the world will say he is a real success. This man would never change places with any man who has earned an extra dollar because he has made the work cost a little more.

For argument's sake let us forget the human being and deal with the question scientifically, if I may so term it. We all admit the "law of supply and demand" fixes the price of everything. A cost-plus contract is obligated to no such law. The "survival of the fittest" is another law that the years have not been able to change one iota. This law must also be ignored in cost plus work because the standard of success has been removed.

After all is said and done, a contractor has certain merchandise to sell. If he does not know its value, he certainly ought not to be able to sell it.

Percentage Work and Straight Contracts.

By James W. Rollins.

I do not believe in any cost-plus or percentage contract, unless there is great uncertainty as to the work to be done, or the cost of labor or material.

Great prominence has been given to percentage contracts because under war conditions, and especially as to work done for the Government, they were the only practicable form to be used, where work has to be done regardless of cost. The Government work was honestly and reasonably done, though no real contractor would "stand for" the inefficiency of labor that had to be used on these jobs. When carpenters, so-called, may be "botch carpenters," barbers or grocery clerks, and come to the contractor as union men, the Government accepts them, but no contractor would. "Put on men" is the slogan, and men go on, whether or not they know what an auger is other than to describe it as a tool that you "turn round and round," or to whom a crosscut saw is the same as a rip saw. It looks well to show 1000 men on reports as working, though 500 good men would do more work.

Our corporation up to war times did practically no percentage or cost-plus work, and never sought for any. We were ready to gamble with our own money and brains, and take straight contracts; and in 20 years of work, which covered some of the most difficult work done in New England—mainly water work—our losses were very small, and our profits satisfactory. In my judgment, percentage work of any kind tends to laxity on the part of both the engineers and contractors.

In straight contracts, the engineer must make his plans and specifications with great care, so that the contractor knows just what he has to bid on, whereas if the work is done on a percentage basis, he can start with indefinite plans and change anything at any time and at any place. And the contractor cannot feel the responsibility or interest in the work when he feels that plans may be changed or that the engineer or owner is liable to come around and tell him how to do the work; when the contractor, knowing that the engineer or owner thinks differently, but must pay the bill, changes his plans and does the work, probably at greater expense, in the way his clients want. In one large job we did on a percentage basis, the engineer took entire charge and neither our superintendent nor myself were asked or consulted about the ways or means; so our fee was paid for us for tool and plant only, and our experience went for naught.

Another fact that I have repeatedly noticed, is that when work has been done on a percentage basis, the engineers and inspectors have allowed material to be used, and work done, which they would immediately have condemned if the contractor had been responsible for it. There is a reason for this. In percentage work, theoretically, the engineer and his inspectors want the work expedited, and so if a pile is 12 in. instead of 14, or a foundation is an inch or two out of line, they let it go, rather than delay the work; whereas were it done by contract they would insist on exact compliance with specifications and plans, and let the contractor pocket the loss, and make up for lost time.

I cannot see any more satisfactory way for an owner to have his work done than under a suitable contract with complete plans, with the contract in the hands of the lowest responsible bidder. There is no excuse to offer if work, either public or private, is awarded to an irresponsible bidder or to one without proper experience; and it is no justification to an engineer to do work on a percentage basis from fear that a poor contractor will get the job, when he has or should have the power to throw all such men out.

Percentage work can never be used for public work except in extreme cases, and, in my judgment, only in cases where work is indefinite or where the owner doesn't care for cost, or where the engineer thinks it easier to make his plans after the work is done.

A contractor is successful only as he makes money, and to do this he must use all his brains and resources to meet the demands of his work. He is alert to study all conditions, acquaint himself with what other men are doing, of the best plant and appliances available. The better he does all this the more money he legitimately makes by reducing the cost of the work. There is not this incentive when work is done on a percentage basis, for on that class of work cost does not come in and but few engineers and almost no owners know whether the cost of the percentage work is low or high, and all they do know is that the work goes along well and the contractors are honest men and good fellows.

As an illustration of Government war contracts: The Navy Department asked for bids on piers in Boston, and got one bid of $500,000. This bid was thrown out and new ones asked for. I told one of the Government representatives that we would do the work on the same basis as we were doing the Army base work, and my judgment was that the work would cost $300,000. The Navy Department would not do percentage work, so we made a bid of $440,000 and were the lowest of three bidders. We didn't get the job, because the money appropriated was not enough.

Any man who does only what he plans to do, is a failure. He must do better than he planned. So with contracting, it's a glorious game for a true sport; to be given a contract of great difficulty; to plan how he will do the work at a given price; then, as he does the work, to find some better and cheaper way; to beat Nature and the elements at their own game, and finish the work with a greater profit than he figured. Is it not reasonable to think a contractor plays the game better, on the above basis, than one who takes a contract with a fixed low percentage? He has no boss to tell him what to do, or to find fault with him if something goes wrong; and if he wins out the glory and money are his. To me that's the game—real contracting; any man with a reasonable amount of brains can do most anything in time, if some one else will pay the bill; but there is no sport in that kind of work!

If some of the contractors who do practically only percentage work would give us their experience in bidding on work on regular contracts, we would get a better idea of the relative value of percentage and straight contract work. I have never heard of their being successful bidders on any public work, and do know of their reputation of being high bidders on private work. Engineers compare cost of work estimated at the cubic foot contents of a building. Unless buildings are of the same general plan, equally accessible to transportation, to material supplies at equal prices, to equal labor conditions, comparisons are invalid, and yet the percentage men gage the efficiency by these comparisons, and they satisfy their principals by them.

Regarding contracts: Most of them have some blanket clauses which are objectionable, but in our experience we have never been held up by them, and the courts are now looking with disfavor on them. They should be eliminated, and also those other clauses which make the engineer final arbiter. As a matter of fact, I do not think his position is ever maintained unless the questions go to court, and even then testimony is generally able to qualify his decisions.

I have had two kinds of experiences on percentage work. One where the engineers want to run the job; in which cases I have had no interest, and about as much satisfaction as buying and selling shoestrings. In other cases we have been given work, without cost and without price simply told to do it at our own price and according to our own plans; and on these contracts I have worried more than on fixed-price work, and do not care for the responsibility of inspector and engineer, of explaining some item of cost, of why something went wrong, with the plant or men or natural conditions. For these reasons I do not care for percentage work, and have no great interest in it.

Rapid Transit Work in New York City in 1919.—Rapid transit facilities in New York City were materially increased during 1919, according to a resume of the construction work under the dual system contracts during 1919, by Transit Construction Commissioner John H. Delaney. Track mileage of the two operating companies increased 35.13 track miles during the year and indications are, according to Commissioner Delaney's figures, that 69½ track miles will be added during 1920. The Interborough facilities were increased by 15.77 track miles during 1919, and the New York Municipal (B. R. T. system) was expanded 19.36 track miles. Thirty-seven construction contracts, involving approximately $16,000,000, are under way at the present time, upon which work amounting to about $10,000,000 was done during 1919. Approximately $10,000,000 worth of work remains to be done on these contracts before they are completed.

Future Methods of Financing New Railroads

With the present uncertainty as to the future of the existing railroads in this country is another question of very great importance as it affects in a vital way the future development and prosperity of considerable areas which must inevitably be served with much better transportation facilities than exist at present. Vast areas of land not now possessing any railroads whatsoever will in the course of time be opened up to settlement through improved methods of farming or by reason of irrigation projects; the many present known deposits of minerals, as well as those certain to be discovered later, will require, it is believed, railroad facilities of some sort in order that the various resources may be made available to the human race in the most economical way.

It seems reasonable to expect that some of the past methods of promoting and financing railroads will be modified somewhat in the future in view of the changed conditions. It is quite certain that some of the earliest methods are practically out of the question, as for example, the government subsidies such as were given to the early transcontinental lines. The Union Pacific received $16,000, $32,000 and $48,000 per mile in bonds, according to the nature of the country and in addition 20 sections of land per mile. The government was rich in land in those days; today the little public land which could be granted to a railroad by way of subsidy would not go far in helping to pay its cost. The transcontinental lines of the early days were recognized as being a national asset and worthy of national aid and the present generation should be thankful of this early recognition. In the extension of railway lines into undeveloped country today it does not appear that such projects can fairly claim aid from the national treasury, as they will be of only local importance, relatively.

In the past numerous methods of assisting the construction of railways have been used by private individuals and by various committees and other organizations of individuals. Right of way has many times been freely donated, land for terminals has been given by way of a bonus, and sums of money in cash have been raised by boards of trade, chambers of commerce and other organizations, and turned over to the railroad when, by virture of a previous agreement, it had laid its track and had run the first train into a given town. These methods are well enough in their way and undoubtedly can be used in a similar way in the future but at most they cover but a portion of the total cost of construction.

Much of the railway extension in the past has been done by "parent" companies pushing out into undeveloped country with branch lines which served as feeders to the main line, and these branch lines in many instances were cheaply built and cheaply maintained until in the course of a few years enough traffic developed perhaps to justify improvements. Very many of these branch lines built in this manner have failed to pay operating expenses and have been carried for years as a loss in themselves but in "feeding" the main, have had their finances merged with the parent company. Of late years there has been less of this sort of extension than formerly on account of the generally unfavorable condition of railway finance. In this connection it is of interest to note that the good roads enthusiasts have gone so far as to claim or predict that when the national highway system shall have been developed and extended, that the "short haul" on the railroads will be nearly, if not quite, eliminated by the substitution of motor truck hauling for all distances under 100 miles. The highway is built by public funds; perhaps it may serve as a branch to a railroad in a way scarcely dreamed of a while ago; and perhaps the railway financed by private funds, could well afford to contribute something to either its first cost, its upkeep, or both.

It has been suggested that counties or states can acquire the authority from the people, if they do not have it already, for issuing bonds to pay the entire cost of a railroad project, and could then lease it for private operation if desired, under proper restrictions. An analogy between this proposition and that of a drainage district has been suggested in that the area benefited by the railroad could be assessed an amount sufficient to cover the cost of construction, or an amount sufficient merely to assure a fair return on the capital invested after the road is built and begins operation.

SCIENCE OF MANAGEMENT

Application in Civil Engineering and Construction Fields

The term Science of Management was coined by the editor of Engineering and Contracting and first used in "Cost Analysis Engineering" (1908) and explained more fully in "Cost Keeping and Management Engineering" (1909). The last named book, which contains ten laws of management and many subsidiary principles, was the first book on the science of management. In the columns of this journal many additional laws, principles and detail methods of management have been published. This section, which appears weekly, may be regarded as a serial sequel to the two books above named.

Items Entering into Present Relations Between Employer and Employee*

By A. L. DE LEEUW.
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Unrest among the laboring classes has taken on such proportions and is so widespread that it is timely to discuss the various items which enter into the present relations between employer and employe. Many times one or both parties in the conflict try to befuddle the third party, the general public, by statements which are misleading or which are couched in such words as will hide that which is not true. It is well recognized that where two parties have a difference of opinion the first step should be to find some common ground from which to start, and that then the second step should be to define clearly and precisely the chief terms which enter into the controversy. We read practically every day about war between "capital" and "labor," about the demand of the laboring man for the "right to organize," and of his right to insist on "collective bargaining," and yet these three terms, which are perhaps used in every controversy that comes up, are not only not defined but they are actually misleading in themselves.

War Between Labor and Capital Should Be Impossible.—If war between capital and labor means anything at all, it must mean war between capitalists and laboring men. Capital is the result of past labor used progressively. Without capital, civilization is unthinkable. Capital is the tool with which the laboring man works. There can no more be war between labor and capital than between the laboring man and his tools. There are a large number of people who actually believe and act upon the idea that capital must be destroyed in order to give the laboring man his own. The fault lies with the capitalists or to the present system of control of capital, not with capital itself.

In late years the control of capital has been more and more centralized, or, in other words, in the hands of fewer individuals. And though it is well recognized that this condition has its advantages in many ways, yet the dangers to which such centralized control may well lead have caused it to be regarded with suspicion and enmity. Capital being the tool with which labor must work, it is but natural that labor should look with suspicion on an attempt to corner the tool supply. For this reason we may naturally expect that labor will insist upon a better control of their tools, namely, capital.

It has been pointed out many times recently that there are really three parties, not considering the general public, which have a right to be heard in this controversy, namely, capital, labor and management. It seems to the author that this merely leads to complication without any compensating features. Management and labor are both labor, but of different kinds. If at times they clash, it is not due to unavoidable conditions, but merely to defects in one or the other.

The Right to Organize.—Another term quite familiar to all of us is the "right to organize." The writer does not believe that there is an appreciable percentage of employers who would deny their employes the right to organize; for instance, for a baseball team, or a brass band, or sick benefits. On the other hand, nobody would blame the employers for denying their employes the right to organize for the purpose of burning down the plant, or sabotage in the shops, or blowing up the works of his competitors—however beneficial this might be to him in a business way, or for many other purposes. It follows, then, that the "right to organize" must be further defined or at least limited in its scope before we can judge as to the real right of the employe to organize. If the purpose for which the employe wishes to organize is legal and proper, the third party, the general public, will naturally concede this right, and quite as naturally inquire as to wether the employer has really denied this right to his employe.

The facts in most cases where this right to organize has been brought to the foreground, are these: A labor organization, acting within its rights, succeeds in gathering into its union part of the employes of a certain establishment. The employer, fearing that this activity may lead to a strike, attempts to keep the other employes from joining the union; in other words, he tries to organize them with him, instead of with the union. He also acts within his rights and cannot be said to have denied his employes the right to organize. It is doubtful whether in late years there have been many cases where the employer has denied the employes the right to join the union, even if he was not in favor of it. When undesirable conditions or relations existed between employer and employe, or perhaps when union activities led to a strike, it was quite customary to make a demand on the part of the men for the right to organize—yet this right had seldom been denied; but, put in this way, the general public would get the impression that all kinds of organizations of the employe are taboo. What is really meant by the "right to organize" is that the employer shall give, not to his men, but to some labor union, the right to come into his shop and organize his men into a union; which is very different from the idea which the expression "the right to organize" conveys.

Collective Bargaining.—Another term which is misleading, even more so than those mentioned before, is "collective bargaining." In collective bargaining it is supposed that some or all of the employes have delegated the right to bargain for them to some attorney or business agent. In practically all cases this business agent is their union, and this union is, according to the term used, supposed to bargain with the employer. As a matter of fact, however, there is no bargaining, and, under the present conditions, there can be no bargaining. There have been cases where the men were entitled to all they asked for, and possibly more; there have been cases where the men were not entitled to as much as they asked for, but the method of bargaining has never been employed, and, in the writer's opinion, could not have been employed, to settle the differences, because the essential feature of bargaining, which is a process of readjustment of the value of the object of barter in the minds of the two parties concerned, is lacking. The issue has been brought to a conclusion by strikes, or threats of strikes, which is no more a method of bargaining than when a man points a gun at his debtor in order to collect a bill.

In order that there shall be true bargaining, there must be an object to be sold, an object to be given in barter therefor, and an attempt of buyer and seller to modify each other's conception as to the value of what they are offering. In offering labor and demanding money we have no measure nor can we estimate its value by personal observation, as we can in purchasing a house, except after the labor is done, which is long after the so-called bargaining took place, long after the price was set. It is true that labor is sold by the hour, but the hour is a measure of time, not of labor.

At the present time labor is not sold by measure, but a workman sells his time. This inability to strike a bargain because the value of the product to be sold is entirely unknown, is, in the writer's opinion, one of the greatest difficulties to be overcome before there can be an equitable adjustment of the differences between employer and employe. The fact that labor is sold by the hour is equally unjust to both parties. Sometimes the employer suffers, sometimes the employe. In all cases it is a source of curtailment of production, and this leads at once to a discussion of wage system.

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*Abstract of a paper presented at the annual meeting, Dec. 2 to 5, 1919, of The American Society of Mechanical Engineers.

System of Payment.—"Wage" is defined as remuneration for work done, and also as remuneration for time given. The second definition seems to be defective. In the first place, when money is paid for time given, it is called "salary." In the second place, and this objection is more serious, time alone is not bought or paid for. There are many occupations in which the employe must wait until something turns up for him to do, and then he is supposed to do it. Besides time and labor there enters into such cases the requirement of physical presence.

There are cases where, practically speaking, time alone is sold. Such is the case, for instance, with a stationary watchman. Even in such an extreme case something more than time is paid for: the man's watchfulness and faithfulness. In other cases time and labor are paid for: for instance, with a machinist's helper, or a blacksmith's helper. In still other cases time and skill are paid for: for instance, the man running a large planer or boring mill. The writer cannot think of any case where wages or salary are paid for time alone.

In the great majority of cases it is labor that is wanted, or rather the results of labor, and not time. The great problem is to find a measure for this labor, in order to obtain an equitable way of paying for it. In even the simplest operations of labor there are so many factors which modify the result that it is difficult to establish a unit of measurement. In some of the more complex work it has been possible to subdivide the operations to such an extent as to set a fixed time for a given operation. But even in the very simple operations some factors enter which will cause trouble at times—trouble with the machine, breakages, replacement of tools, and the like.

In a large portion of work there is a combination of time, physical presence, labor, skill, knowledge, judgment, and probably other factors which are hard to define, such as reliability, steadiness, enthusiasm, loyalty, ambition, and whatnot. To make up a formula which would embody all these elements and from which a man's value could be calculated is, of course, impossible. The impossibility of a mathematical solution shows the necessity for the development of a compromise system.

There are various systems of payment in existence at the present day—there are straight wages, piece-work system, various systems of bonus payment, premium payment, and combinations of these systems.

Wage System Considers Nothing But Time and Physical Presence.—A man is selected for a certain task because he or some one else claims that he is fit for that task. If his work is satisfactory he is retained; if not, he is dismissed. Both employer and employe have made a guess. The employe knows exactly what he will get, and guesses at what he will have to deliver. The employer knows exactly what he must deliver, and guesses at what he will get.

With the piece-work system the employer knows exactly what he will get for his money, but the employe makes a guess as to how much he can reasonably do; he has no control over the conditions which will enable him to do, or prevent him from doing, as much as he is expected to.

There are various kinds of bonus systems. The employe may earn his regular wages and get a bonus at stated intervals if his work exceeds the expections of his employer; or he may be working under the task-and-bonus plan, in which case there is less guessing and more of an attempt at a definite bargain. If the employer is in earnest with such a system, and sees to it that it is possible for the employe to fulfill his task, then this system approaches quite closely to true bargaining.

The premium system is an attempt at gaining the interest of the employe by making him invent improvements in the method of working and sharing the profits with him; but unless the time originally set was carefully studied, and unless all conditions of machinery, tools, existing knowledge, and so on, remain unchanged, this system also will lead to controversies and injustices.

To sum up, the pure wage system is no bargaining in any sense of the word; the piece-work system is only bargaining if employer and employe have reached an agreement, and if there is some mechanism by which this agreement can be changed as soon as conditions change; the pure bonus system is nothing else but a wage system with a kind of profit-sharing plan; the task-and-bonus system, if properly worked out, and if accompanied by complete instructions to the employe, is a perfect bargain, but must be constantly revised as conditions change. However, this system carries with it the necessary mechanism to effect these changes.

Labor Unions Are the Army With Which the Laboring Man Fights the Employer.—If fighting has given them, if not all, at least a large portion of what they desired, it is but natural that they should consider war the best means of reaching their ends. The unions, so far, have not offered any constructive suggestion, and this cannot be expected from a fighting organization. Furthermore, it is to the personal interest of union leaders to hold to this system. It may be taken for granted that there have been, and are, many unselfish union leaders, but this does not offset the general tendency of the system to perpetuate itself as a fighting organization.

Another reason why the attempt of the employer to put labor on a contract basis has not been well received by the labor unions, lies in the historical fact that on account of occasional scarcity of work it became one of the principles of the union to take measure to insure that whatever work was available should be sufficient to keep the union men in employment. The three chief means used to accomplish this were: first, to prevent anybody but union men from working at the trade; second, to limit the number of apprentices, or in general, newcomers in the union; third, to limit the output per man. The second item has not been strictly adhered to, because it was found that by limiting the number of men in the union the number of men outside the union was increased, thus decreasing the relative fighting strength of the union. The first item has been strictly adhered to, but has often been denied by the union, probably for the purpose of satisfying public opinion. The third item is still generally adhered to, but is mostly camouflaged. Taking the aims of organized labor to be:

1. Proper share of the proceeds of labor,
2. Reasonable working conditions and working hours,
3. Right to organize,
4. Collective bargaining,

the writer believes that these aims could all be accomplished without strife if the last item, collective bargaining, were put into actual practice instead of being a mere catchword.

If employers and employes together would put as the first item in their catechism the truth that the world must produce more in order to have more, if employer and employe together would try to find an equitable way of estimating the value of work done, if both would subscribe to the truth that no permanent gain can be made by wearing out a man's capacity for work nor by allowing him to work less than he should for the good of the world at large, if then employers and employes together would organize a Bureau of Research for defining the conditions under which various classes of work should take place, and if, finally, an attempt were made by both employers and employes to classify men according to their natural or acquired ability, there would be very little reason left why a union should be a fighting organization.

Solution Lies in Establishing Proper Wage System.—Up to the present time the unions have acted entirely through their business agents, who sometimes had, and more often had not, a clear idea of the problems involved in the trade they represented. Whatever knowledge they might have had was not permitted to come to the foreground. It seems to the writer that the time has come for the unions to take the first step along the lines of considering union activities as a legitimate business, and legitimate business cannot shut its eyes to facts, however disagreeable to contemplate they may be. It is his belief that the crux of the solution lies in the establishment of a proper wage system, and that in order to establish such a system the engineer must come to the assistance of labor in order to find standards of value for work done. Though it is not likely that there will ever be a time when every human activity can be scheduled and analyzed, yet by far the greater part of industrial operations can be treated in this way. The relatively few operations which cannot be classified and treated in this manner would be such a small part of the total that it would be easy to find a way to compromise when such exceptions should occur.

In estimating the value of operations we must drop, to a large extent, the idea that wage is the compensation for time. It should be made a compensation for product delivered. The value of the product changes constantly. Changes may be due to the desirability of the product, or to the means employed to produce the product, or to the law of supply and demand, or to other causes. In order words, the relations existing between various products is everchanging; consequently, whatever estimate is placed on the value of the product of labor should be changed from time to time, so as never to have too large a difference between the actual and the estimated value.

It hardly need be pointed out that to set such standards of value of work must necessarily be a gigantic task. In addition to the many technical difficulties in estimating values of products, there are other elements which must not be forgotten. There are many cases where operations are required which call for extreme skill, possessed by only a few, a skill which can never be found in the mass of the people. There are operations where steady nerves are essential, some where physical courage is required, others which cannot be successfully carried out without many years of experience, etcetera. Such points should all be considered.

Consideration should also be given to what constitutes a proper minimum and a proper maximum wage. In repetition operations it is sometimes possible for the operator to produce large amounts of work, but only at the expense of extreme weariness, and in the long run such a man is not employed to the best advantage of the world at large. Recognition of this fact has led to the prescription of rest periods. On the other hand, there may be cases where it is expedient to employ men not skilled in the operation they are supposed to do. This may happen because skilled men are not available at that time or at that place, or because special conditions call for an unsual amount of this class of work. Though the value of the product of such a man might be low, he should receive not less than a minimum wage. This minimum wage, however, is in itself difficult to determine. A satisfactory minimum wage for an unmarried young man is not at all satisfactory for a married man with a large family.

It is really superfluous to point out the many disturbing factors acting against the establishment of wages in proportion to product. What the writer wishes to emphasize is his belief that, notwithstanding all the difficulties, it will be found possible to classify a large portion of the work of the world in such a manner that wages can be set to such a degree of scientific accuracy that the variations caused by the disturbing facts will not be so large but that they will lend themselves to compromise. It is further his belief that such a classification cannot be accomplished by the employers alone, nor by the laboring men alone, but that when these two classes are working together for a constructive purpose, they will find so many things in common that they will be more apt to forget their differences. Finally, he wishes to state once more this belief: That the real cause of the present-day unrest lies in the fact that there is no unit of measurement which both employers and employes can use; or, in other words, the fact that our present wage system is not based on knowledge and justice, but only on guesswork and on fear that the one may "do" the other.

More Women Than Men in Railway Offices.—A study covering 11 railway offices in various parts of the country shows that 51.1 per cent of the employes in these offices were women. Offices of various kinds were included in order to make possible the examination of different classes of position. The list includes five types which are given in the following table, together with the number of men and women employes:

Name of office—	No. of employes. Men.	Women.	Per cent women.
Car accountant	74	268	78.3
Freight claim	91	86	55.0
Freight auditor	985	979	50.0
Local freight	100	97	40.0
Auditor disbursements	211	98	32.0
Total	1461	1528	51.1

Industrial Economics[*]

By HAROLD ALMERT,

Consulting Engineer, Chicago.

Since the beginning of the European war the mental attitude of labor toward its work, toward its employer and the public has changed. The desire to serve has gone, the desire to strive for efficiency, for efficiency's sake, has gone, and instead the desire seems to be to deal with its employer at arm's length and each day bargain for a shorter day, higher pay and less work.

With the increasing cost of the necessities of life the working man obviously has had to have material increases in pay, and in so far as the increases went to make up for the increased cost of living there is no cause for complaint unless labor itself by its own acts has been responsible for the increased cost of necessities. To anyone that has made a study of commodity prices it is obvious that pre-war prices for labor and material will never return. The sooner we all realize that the sooner we will begin to progress again.

Nevertheless, commodity prices must come down in this country if we hope to keep our place among the industrial nations of the world, and in our effort to bring down commodity prices care must be exercised that we do not reduce still further the purchasing power of the workingman's dollar, but rather increase it and make every effort to bring it back as nearly as possible to what it was before the beginning of the European war.

Industrial engineers have studied and written much on increased productivity of labor and machinery. In a great many cases their efforts in improving production by the aid of new and improved machinery has shown remarkable results; but the cases recorded where the productivity and improvement in human efficiency were obtained are very few and far between. In other words, in the last decade the wonderful improvement in production may be nearly all credited to improved methods and machinery and very little to improved efficiency by human efforts.

Take such a simple task as reading, for example. Repeated tests show that with men or women of equal training and experience one man or woman will read four times as fast with equal accuracy as another. F. W. Taylor observed that "A first-class man in most cases do from two to four times as much as is done on the average." His conclusion applies to all trades and is not based on a spurt or period of over-exertion. It was simply what a good man can do and keep up for a long term of years without injury to his health, but become happier and thrive under. Professor Scott observes that the "men who know how to get maximum results out of machines are common; the power to get maximum of work out of subordinates or out of yourself is a rare possession."

The productivity of the individual must be increased to bring down prices. If it can be shown that labor is primarily the cause of increased prices and that labor can, without injury, restore former conditions and even materially improve them, then it is up to labor and we must look to labor for the solution of our present conditions.

Let's just look at a few examples to see if labor can materially reduce costs and prices.

Of the commodities that increased the least during the war, public utility service is the best example; by that I mean the cost of service to the consumer. The cost of rendering the service went up like all other lines. From a recent study of the cost of labor on pole line construction for telephone and electric light companies the following conclusions were drawn:

Year.	Rate paid per hour weighted average, ct.	Time to do work.	Per cent of increase on time, 1912—100%.	Resultant labor cost per hour ct.
1912	25	25 M	100	25
1913	25	25 M	100	25
1914	25	22 M	88	22
1915	27½	20 M	80	22
1916	30	28 M	112	33.6
1917	35	32 M	128	44.8
1918	42½	42 M	168	71.4
1919	50	49 M	196	98

I am reliably informed that before the war 20,000 men produced 40,000 automobiles in a month in Ford's plant, which today it requires 35,000 men to produce 20,000 cars, an almost unbelievable reduction in human efficiency.

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[*] From a paper presented before the Western Society of Engineers.

During the war coal operators in Illinois made a handsome profit under the government price of $2.35 per ton for mine run. Under patriotic appeal the miners worked full time every working day. The mines were operating at 100 per cent load factor. Then came the armistice, everybody let down and everybody relaxed. Miners had accumulated a great deal of money, they began easing off, so that in 30 days the production had dropped to 33 to 40 per cent of the maximum. The cost of mine run at the mine due to reduced production ran up so that the operators instead of making a handsome profit actually suffered a loss on the government price.

Take another example of cost of construction. For illustration a study was made of the cost of steel, cast iron, labor and other materials that go to make up the cost of building a gas plant and distribution system. Taking the costs in 1910 as 100 per cent, the costs in 1918 were found to be 87 per cent higher. Here again part of the increased cost was due, in a large measure, to the decreased efficiency of labor.

One telephone company found that before the war installers would put in five to six telephones per day. Now the installers get twice as much pay and install only one telephone per day. Therefore, the total installation cost is 10 to 12 times higher than before the war.

If the above cases are true and labor has done much more work in the past and without detriment to health and happiness, and if this is the first step, if indeed not the only one that will quickly and effectually begin a reduction of costs and prices, is it too much to ask labor to lead off to restore former conditions? If it is true that labor caused the present condition not wholly but in a large part, then isn't it reasonable to expect labor to put its shoulder to the wheel and start the improvement rolling? Will labor by simply directing these conditions to its attention apply the remedy? I think I can say without fear of contradiction that it will not. If labor was free and unshackled? Yes, but the parasites who mingle with labor and rule labor and who are responsible for this condition of unrest will never consent to a return to former conditions when we were seeking to improve human as well as mechanical efficiency and to measure compensation on the ability or productive capacity of the individual. Constructive progress cannot be hoped for with labor's present attitude. The radicals and parasites who now control and speak for labor have to be routed and the intelligent and conservative element returned to control. When labor regulates itself, productive capacity and quality of labor will be recognized. At such time the introduction of both financial and non-financial incentives will stimulate productive capacity. Due to constant agitation of radicals, labor is not only indifferent but actually hostile to the introduction of principles and elements that will bring about lower costs and prices. Therefore, the methods used in the past will not suffice but a thorough understanding of psychology applied to business will be necessary.

The wonderful growth of the steel business was due to competition for efficiency with achievement and production as the goal. Professor Scott tells us that the Carnegie system was one of the most comprehensive applications in business of man's instinct of competition to the work of increasing individual and organized efficiency.

Almost any business man can build and equip a factory with efficient machinery, but the man who can select a force of men to operate that machinery, train and bring them up to the maximum production and then maintain it, is rare. The big problem which we all have to face is to make a closer study of human nature and in the future make more accurate selection to insure getting the right man in the right place. Then prove to him that he can produce two to four times as much in the future as he has in the past, and while so doing, study him, make his work interesting so that he will be contented, all of which is, of course, easier said than done.

Wide Tires Facilitate Wheel Scraper Work in Sand.—In excavating in sand at Indiana Harbor, a contractor used No. 2 wheeled scrapers with specially constructed wheels having 6-in. tires, with the result that the yardage handled by the outfit was greatly increased.

Eliminating Hand Written Public Records

Manuscript in the making of public records has passed its age of usefulness, states Mr. Frank C. Merritt, chief deputy city clerk of Oakland, Cal., in a paper read before the Department of Clerks, Auditors and Assessors of the League of California Municipalities.

No modern public office should permit the record of its works to be written by hand. The typewriter and the printing press must be substituted for the antique, inefficient and laborious pen and ink in order to procure uniformity.

We daily puzzle over the handwriting of predecessors in office. We delve into old record books and endeavor to decipher the hieroglyphics of those who kept the records. We envy the excellency of the Spencerian exponent who formed his letters so well. We follow further and discover that he was evidently sorely overworked, for he employed great patterns of rubber stamps to fill in the oft-repeated phrases of headings, conclusions, etc., and we believe from our examination that he first wrote carefully and then stamped carelessly, for many of the letter markings are illegible because they were too hastily used.

Subsequently city officials secured the services of expert stenographers and they used book typewriter machines to make a perfect compilation in printed words of the old books in which had been written many pages of manuscripts. This method was satisfactory for voluminous records, but we still found it easier to make our index by writing in it, for it was a nuisance to carry each book to the machine and set it at a certain angle in order that only a few words might be typed therein.

Then some one invented a loose-leaf book with a binder that could be permanently locked when the book was completed. This solved the problem, and we discarded the old book typewriter machine and the manuscript forever. No matter what size or shape the book, the loose-leaf pages permit the keeping of uniform records.

There is no puzzling over handwriting peculiarities, no indistinct rubber stamps to decipher, and no effort need be made to decide marks made by lazy clerks.

Advantages of Machine Billing in Railroad Offices

Machine billing is an early method of using labor-saving devices in railroad offices. The advantages of this method are obvious. A bill clerk billing by machine can accomplish nearly three times as much as the hand bill clerk, and in addition turn out much better work. An interesting example of the speed and economy with which billing is done on machines is cited in a recent issue of the Railway Review.

The New York Central's West Albany transfer station employed eight bill clerks. They billed in one month 64,000 waybills, covering 76,000 shipments. The cost of each waybill, including the typewriter, cost of comptometer, carbon clerks, one clerk supervision, two and one-half clerks comparison, three rate and route clerks, was .018 ct. per shipment.

Billing is done on a piecework basis, but instead of operating on a penalty system by deduction for errors made by each of the billers, the bill clerk is required to look up each error made by him that requires a correction at a time of the day when the better class of billing is to be given out, and after looking up the error he is required to give an explanation to the agent or chief clerk. In this manner the clerk who has a clear record has the advantage by being able to proceed and is not delayed in looking up the error. In this manner errors have been reduced in this office to one in each thousand shipments waybilled. During one month when 76,276 waybills were made the percentage of errors, including rates, extensions, billing, etc., was .012; in the following month .011. One of the bill clerks waybilled 5,439 shipments with but one error. Another clerk billed 3,709 shipments in 14 days, making but one error, and another clerk billed in 6¾ hours 541 tickets, re-billed from connecting lines. An error book is kept in this office on all bill clerks, each clerk having a number and separate page in the book. Of the 76,000 shipments during the month in question the percentage of error was .012. The error allowance is one mistake in a thousand.

Maintaining an Engineering Force in Dull Times

During the dull season of 1914-15, when there was practically nothing to do, Westinghouse, Church, Kerr & Co., Inc., kept its executive and technical organization practically intact. "There was nothing merely humanitarian in this," states Mr. J. C. Boyd, vice president of the company, in an article in System. "It looked like good business to us. And that is what it proved to be. When the tide turned in 1915, we were ready. We had none of the tribulation of building up and working with a new organization. True, we had to take on thousands, tens of thousands of new men. But everywhere over them and among them were men who were used to working with one another, men who knew our way of doing things, men whose abilities we knew.

"And these men were not only already broken in; nearly all of them stayed with us, in spite of the fancy war salaries that were offered to hundreds of them. They were loyal for the simple reason that we had been loyal to them. I do not think they were any more sentimental in this than we had been in keeping them on the payroll during the dull year. That year and the other periods of depression which they had passed through with us had brought home to them the value of permanent employment.

"For several months of the year 1914-15, we had red figures on our balance sheet from following this policy. When there was every temptation to cut our force as much as possible, we faced in the opposite direction. We spent our time figuring out ways to keep the force as big as possible. There were some discharges. We couldn't avoid them. But we managed to keep together an executive and technical force of 350 men, during all those months when there was practically nothing to do.

"I regard the transmission of a sense of economic security to the members of a force as a preliminary to organization, as something which must be done before the force can really be organized.

"The three points to me in organization building are these:

"1. Give an economic security by not being afraid to cut into profits.

"2. Make honest work the standard and the measure of ability; that will breed organization honesty.

"3. Give plenty of responsibility to the individual and guide him rather than force him through supervision. Make supervision a mutual and not a zone affair which will banish the 'no man's land' that sometimes stretches between departments."

Improvement in Efficiency of Construction Labor

Recent cost computations made by the Aberthaw Construction Co. indicate that construction labor for that company at least, is getting back into its prewar state of efficiency.

"It is too early to venture any broad generalizations," says Dan Patch, statistician of the company, who has been making these computations. "Yet I feel justified in saying a word of what should be encouragement to those who see only gloom in the labor situation.

"The Aberthaw Co. keeps very carefully tabulated data of unit costs on different jobs. These it uses to establish averages that shall be available in checking the relative efficiency of subsequent undertakings. In figuring labor costs per unit of accomplishment, it is, of course, necessary to adjust the wage rate to a common standard. Hence, the computation really expresses itself in terms of labor hours expended on a given unit.

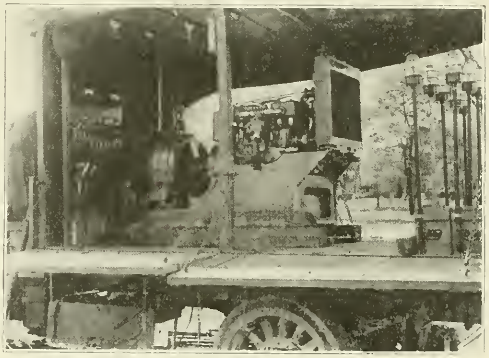
"During the war, labor costs, both relative and absolute, went alarmingly skyward. How much of this was due to dilution of the trades through the injection of vast numbers of unskilled workers, how much to sheer war demoralization, and how much to profiteering through shirking, no man can say. The fact remains that costs were high.

"Now they are coming down again. That is to say, carpenters, masons, painters, and glaziers appear to be turning out as much work in an hour as they did before the war. In certain of our jobs, even, there are faint indications of improvement over earlier averages. To be sure, the men are not accomplishing as much in a week—even with overtime added—as they did under a longer working day: 48 hours have not been made as productive as were 54 hours. Nevertheless, there is satisfaction in possessing statistical evidence that during the hours when labor is supposed to be at work it is actually working."

Portable Generator Sets for Operating Construction Machinery

The requirements of the Army during the war brought particular emphasis to the fact that for certain work and conditions an independent portable source of power and light was indispensable. Gasoline engine-driven generators of various sizes were employed extensively to great advantage.

The Allis-Chalmers Mfg. Co., which furnished a large number of these sets to the Government, has now placed them on the market for general use. They make available to the contractor a source of power and light, flexible in application and comparatively cheap. Two sizes have been brought out - a 5 k.w., 110 or 220-volt and a 15 k.w., 110 or 220-volt.


15 K. W. Set Mounted on Army Truck.

These sets employ four-cylinder, four-cycle gasoline engines of the automobile type which are of ample size and rating to withstand continuous full load service without being overtaxed. The engines will carry momentary overloads up to the ultimate capacity of generator without bringing undue mechanical strain on any of the working parts. They are equipped with standard magnetos, carburetors, water circulating pumps, tubular type radiators and fans. Governors are provided which positively regulate the speed to within 4 per cent of the set speed of the engine from no load to full load. The generators are provided with compound windings proportioned so that the voltage variations do not exceed 2 per cent from the set voltage from no load to full load.

The 5 k.w. set has three main bearings; one being the standard ring oiled generator bearing, the other two being in the engine frame. The generator is held in accurate alignment by a rigid barrel housing which is machined to fit shoulders on the motor and generator frames. A coupling on the generator shaft fits into a recess in the flywheel and is bolted rigidly to it. The fly wheel and coupling are enclosed in the barrel housing. This construction gives a very compact arrangement and one in which the bearing alignment does not depend upon the rigidity of the base casting and foundation. In this set the gasoline tank is mounted above the generator with gravity feed to the carburetor. The switchboard is mounted on angle irons attached to the base casting.

The 15 k.w. set, which is shown mounted on an Army truck in the illustration, is in some respects different in construction from the 5 k.w. set. The generator is provided with front and rear bearing housings and is coupled to the engine by means of a flexible coupling. The gasoline tank is rectangular in form and is mounted in the base under the engine. The gasoline is raised to the carburetor by means of a vacuum system similar to that widely used in automobile construction. In this set the switchboard is separately mounted and may be placed in any convenient position.

Advantages of Standard Plans and Specifications and Centralized Control for Government Work*

By BRIG. GEN. R. C. MARSHALL, JR.
Construction Division, U. S. Army.

There are at the present time 27 separate and distinct Federal agencies engaged in the construction of public buildings. There are 16 separate government departments building roads, and 19, which in one way or another, have to do with hydraulics, river and harbor work. None of these agencies are co-ordinated. The standards in one department vary greatly from those in another, and the methods employed in construction and the detail requirements of the mass of specifications emanating from these 62 different sources are too complex, too contradictory, too involved, for any normal man to differentiate between them. The inevitable result is that the government pays the bill in loss of time, in high bids, and in a confusion of tongues worse than that which stopped man's most ambitious and daring building schemes, the record of which may be formed in the eleventh chapter of Genesis. The Tower of Babel might never have reached heaven, but its progress chart would have at least shown better than 5 per cent if that famous confusion over the specifications had never occurred.

There is today but little less confusion on government work than that which existed on the above mentioned job, and out of this condition there is gained a well merited prejudice against government work on the part of those contractors who are accustomed to handle construction in a more direct and businesslike manner.

It is fundamental that in all construction work there are certain elements more or less identical. Certainly there are a large number of operations which can be standardized, and which should not be subject to the whim or opinion of some individual who, for reasons of his own, desires to depart from the fundamentals of common practice. For instance, there is no tenable reason why a standard specification covering the quality of cement, or of stone or of roofing material should vary materially because it happens to be required for work under different government departments. There should be no basis for uncertainty in the mind of the contractor when he bids upon a specification as to what the text of the specification means, and yet, because of the varied language in which even the most commonplace building operations are described, the personal equation of the engineers in the many offices writing the specifications necessarily enters very largely into the contractor's estimate of cost, if he is going to protect himself against such a varying contingency. A standard specification, whose meaning is definite and understood eliminates the expensive hazard of guess-work.

Value of Time Lost Sight of on Government Work.—Until the war we were accustomed to see government projects drag through an interminable period. Buildings which would be completed for a commercial client within six months or a year required two or three years for their construction, largely because of the minutia of the specifications and the details of procedure which had to be satisfied in order to pass a government inspector and secure payment.

The contractor, knowing this, was forced to include in his bid an allowance to cover possible advances in wages and material costs between the beginning and completion of his work and the overhead of his office. It sometimes happens that appropriations authorized for certain work become totally inadequate before the job is well under way and either the contractor goes broke or additional appropriation involving resubmission to congress is necessary to provide the necessary funds to complete the project. Time is the working capital of both the contractor and the government. For every extra day of delay two days are lost. The constructor loses a day's profit or use which would be derived from the completed job. This is true whether the work be private work or public work, for just so long as the building period is extended, just so long will the invested capital be deprived of its earning power, labor rendered unavailable for other jobs, and the use of the plant deferred. A standard plan and specifications and centralized control of the work through a single department would undoubtedly save both time and money for all concerned.

Any idea can be carried to absurd proportions, and no man of common sense will argue that specifications and design should be so standardized as to destroy all originality or prevent improvement, but there is a sensible course between those two extremes which may be readily attained. To say that various operations coming under government control are not capable of such treatment is to use an argument which has long ago been proven fallacious.

Simplification of Construction by Standardization of Plans and Methods.—If government work is to be done at a cost comparable with commercial construction the methods of handling it must keep pace with those in commercial life. Due to the war and the conditions growing out of it, construction work has been tremendously complicated, labor is restless and demands an increase in wage, generally with a decrease in production. The high cost of materials and uncertainty of transportation of many other elements which are entirely outside of the control of the designer, the supervising engineer and contractor all tend toward an increase in construction cost. If these varied elements cannot be controlled the one remaining factor subject to control is the standardization of plans, specifications and methods, so that the building problem is simplified to the utmost and so that labor by the constant repetition of construction process becomes increasingly familiar with the best and most expeditious field methods.

Figuring out just how this can be done with the greatest possible saving has become the principal indoor sport of the successful contractor. I do not believe that there is any immediate likelihood that these conditions will change, for there is a present shortage of from 6,000,000 to 10,000,000 common laborers in this country, due to the curtailing of immigration during the war and its diversion into the channels of semi-skilled worker by reason of the shortage of trained men. Because of this shortage in man power, with its resulting high rate of wage far in excess of anything heretofore experienced, every possible means must be employed to reduce to a minimum the man hours which enter into a building project. No more certain method occurs to me than to reduce the tailor-made feature of every government job to an absolute minimum by the fullest use of standard plans and specifications. The elimination of competition between the government departments, which will certainly come if all work is placed under a centralized control, the discontent among the civilian employes now so apparent in the several bureaus because of the varying salaries paid for work of a similar character as well as the tremendous money advantage which might be derived through a centralized purchasing agency for those government materials such as cement, steel, lumber, iron pipe, plumbing and electric fixtures, common to the work for every bureau are so apparent as to need no comment.

Experiences of Construction Division with Standardization and Central Control.—These generalities are convincing enough. I cannot think of this subject without applying the argument to the vast amount of work handled by the construction division. When I think of the extra cost, the many mistakes and the lack of co-ordination which might have resulted had the 589 jobs under the jurisdiction of the construction division during the world war been attempted without standardized specification and a centralized control, I know that instead of their being made ready for service ahead of schedule time, as many of them were, they would not have been finished until this very day. The vast cost of separate designing organizations at each one of these projects was reduced to that of one organization in Washington, which insured uniform methods, eliminated poor design, permitted quantity purchase, co-ordinated the designer, the field engineer and the contractor, made structural safety certain, predetermined quantities of material, so that the question of buying for any project resolved itself into little more than the adding up of the totals of the smaller units required until the sum met any requirement.

A single contract and a single specification eliminated thousands of disputes over details. The same question arising on many jobs was answered once and for all. Assume, for instance, at the 16 National Army camps, what a diversity of plans there would have been had each constructing quartermaster attempted to set up an organization to produce a tailor-made design for his 40,000-man city instead of having immediately available standard plans and specifications with which to at once proceed toward quantity production. Under such a scheme there would have been 16 separate overhead costs versus one, 16 separate designs for every structure, with 16 strain sheets, 16 schedules, detail contracts, specifications and legal work, versus one, and an equal number of separate plans for the utilities, varying in detail if not in object, a like number of accounts and cost records, none of which would be made on the same basis and therefore of little value for comparisons; 16 separate kinds of everything else, as against one standard plan, and finally a total cost which, by reason of these minor differences, would have been far in excess of that which resulted from construction based on the best and most thoroughly co-ordinated ideas.

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*Abstract of an address presented Jan. 14 before the Convention of National Public Works Department Association.

Special requirements were easily provided for by changes in the standard plan. In 99 cases out of 100, the standard plan fitted the conditions equally as well as one which had all the earmarks of individuality, but which did not necessarily, just because it was an individual design, meet the requirements of those special conditions. For that exceptional case, where a tailor-made structure was absolutely required, the organization which has established a standard practice can prepare a special design for that special requirement far more efficiently than could any individual who had not the background of a vast experience behind him.

Policy in Dealing With Labor.—Another great advantage is the possibility of establishing a fixed policy in dealing with labor.

During the war there were 904 strikes distributed among the several building trades on the work under the jurisdiction of the Construction Division. These strikes were settled by a single section of the Construction Division having charge of labor matters. They were so handled that it was not necessary for them to go before the Secretary of War or the higher authorities of the War Department, and so satisfactory was their settlement that the account of them occupied but a small space in the voluminous reports submitted on our work and they have therefore attracted little or no attention. They were never permitted to get into the newspapers. The public at large did not know of them and I dare say this audience, whose business is directly connected with matters of this character, was never before conversant with the fact that their number was half so great.

Because the same problem was handled over and over again by this section, the method of handling became standardized, and they were so handled that on no single job were these strikes permitted to delay their completion on time. Those handling these matters came in contact with the leaders of labor, established a working relationship, and it is believed, disposed of them to the greatest benefit to the government and with the least upset to the world labor. Naturally, had there been a number of organizations reporting to different heads doing this work there would have been conflict in decision on the same questions and an absolute absence of personal relationship which developed mutual confidence and often times made a quick settlement of a disputed point possible.

Advantages of the Cost Plus Contract.—There has been since the war a great hue and cry raised in criticism of the cost-plus contract. I say to you that so long as the provisions of that contract are definite, so long as there is a fixed sum based on a reasonable estimate of the cost, beyond which payment to the contractor for his services shall not go, and so long as reasonable governmental supervision over the work is maintained, there is no other form of contract which, in time of war, with the resulting unstable market and labor conditions, where work has to be started and organization put on the ground before even the most preliminary plans can be drawn, is flexible enough to meet these conditions.

It is easy to forget the strenuous days of 1917 and 1918 and to revert back to a peace time state of mind. It is our mental habit to measure an accomplishment by conditions which prevail at the moment, rather than by those which actually surround the job, and I know that much of the criticism of the cost-plus contract with its fixed sum limit, such as was used by the Construction Division, is either deliberately unfair or else emanates from a man who fails to vision the conditions under which our war work had to be done. We have long ago abandoned the idea that the contractor is necessarily a grafter because he is a contractor and ceased to contend that all the virtue in the world is concentrated in the army or in the architects or the engineers. There are still honest men and men who do honest work in all lines of work. It is true that in some isolated cases, on our half a thousand jobs, there were examples of extravagance, some unnecessary waste and an occasional failure of the organization to move on a 100 per cent basis, but in comparison with any losses resulting to the government from such conditions, there is offset the saving of an untold amount on the greater proportion of our work, where the work was well and honestly done.

This contract represents the only equitable basis under which emergency war work could be performed. It was the only form of contract which afforded protection to both the contractor and to the government.

Continuance of Railway Boards of Adjustment Recommended

A recommendation for the continuance, even after the end of Government operation of railroads, of the Boards of Adjustment set up by the Railroad Administration to render decisions on controversies arising out of the application of wage orders and on other disputes between railroad officials and employes, was contained in the annual report for the year 1919 of W. S. Carter, Director of the Division of Labor of the Railroad Administration, to Walker D. Hines, Director General of Railroads, made public recently. In the report Mr. Carter states:

"It will be noted that Railway Boards of Adjustment have no jurisdiction over the recommendation, issuance, and interpretation of wage orders, their duties being confined to decisions on controversies arising out of the application of wage orders and to decisions on all other disputes between the officials and employes working under agreements.

"The work of these boards demonstrates not only the advisability of the creation of such boards, but the necessity of their continuance either under Federal control of railroads or thereafter. The fact that the boards are 'bipartisan,' without 'umpire' or 'neutral member,' and all of which members are experts on railroad agreement matters, has led both officials and employes to have confidence not only in the fairness of decisions reached, but as to the technical ability of the members of the boards to pass intelligently upon all controversies submitted for decision.

"Where controversies, sometimes of the simplest character, formerly resulted in negotiations extending over months or years, resulting in strained relations between the officials and the employes, such controversies when not promptly disposed of by the officials and employes are referred to Boards of Adjustment for final decision without any personal feeling in the matter."

A. A. E. Has 12,000 Members.—The American Association of Engineers now has 12,000 members. In addition there are several thousand applications which have not yet been passed upon. During the last year the following local societies have been absorbed and established as chapters of the association: Idaho Society of Engineers, Oregon Society of Engineers, Engineers' and Architects' Association of Southern California, Southwestern Society of Engineers, the Navy Technical Association, Northwestern Society of Highway Engineers, the Engineers' Club of Kansas City and the Engineers' Club of Houston, Texas, Sacramanto, California and several colleges. In addition to this the North Carolina Society of Civil Engineers has voted to amalgamate with the association, and will do so as soon as the details are arranged. The Michigan Engineering Society at its annual convention in January showed a strong desire to affiliate with the association by an overwhelmingly favorable vote (only one negative) to refer the question of amalgamation with the association to its members by letter ballot. With only 25 or 30 chapters and clubs in the first of 1919, the American Association of Engineers has today 105 chapters and 45 clubs.

Earthwork Shrinkage in Valuation Work

How much does "ordinary" earth shrink when put into an embankment? This question when put to most railway engineers will bring the reply that it "all depends" on what particular variety of "ordinary" earth is under consideration, and also upon the method employed in building up the embankment. Many engineers have noted discrepancies between their own observations of this matter and the published results of experiments, or the observations and opinions of other engineers. To men concerned chiefly with construction the whole question of shrinkage, while important to a degree, has not been a specially vital one, because in building an embankment the matter comes up chiefly in connection with determining the extra height needed to allow for shrinkage of the new material after the embankment has been completed. This is quite a different matter from the question as to whether or not a cubic yard of material measured in excavation and used in the building of a fill comes to occupy subsequently a volume less than a cubic yard. This last question, however, has become of considerable importance in the valuation work done by the various state commissions and the Interstate Commerce Commission.

The Public Utilities Commission of Illinois has gone into the matter quite thoroughly and has submitted to the National Association of Railway and Utilities Commissioners a brief on the question of shrinkage. In the brief it is stated that "so doubtful is the claim that earth placed in a railroad embankment will shrink to less than the volume occupied by it in the original bed that it was decided, if possible, to find the basis upon which rested that theory. To this end all available material in the libraries of Chicago was canvassed with the results set forth in the following:

Strikingly outstanding are—

(1) the lack of experimental data on the subject;

(2) the pronounced disagreement among writers, not only as to the amount but as to the very existence of such shrinkage; and

(3) the wide influence of the experiment of Ellwood Morris. While there is not the slightest desire to belittle the results of Mr Morris, nevertheless it seems clear his experiments were upon such a small scale and so lacking in the detail essential to accurate findings that they cannot now, after three-quarters of a century, be properly used in determining a question of such magnitude as that now before us. Further, where there is found such an utter lack of agreement upon a material fact, grave doubts must arise as to its existence. It is therefore imperative that this Commission, before any allowance be made for shrinkage, shall insist upon such thorough proof of its existence and amount as shall set at rest the serious doubts now entertained as to the propriety of the demands of the carriers."

"The lack of experimental data upon so important a subject is lamentable, and such data as exist are based upon quantities entirely incommensurate with the gravity of the issues involved. Most of the evidence adduced in support of the theory that shrinkage exists appears to be based upon hearsay and unsupported by experimental data. Indeed, to such an extent has this been carried, that formulas for shrinkage, based upon such evidence, have been put forth by well-known authors for the guidance of engineers. In at least one instance such a formula was later repudiated by its author. Opinions of engineers, no matter what their professional standing may be, will not settle the matter either one way or the other, and academic arguments, while they may have value, are far from conclusive. Certain it is, if shrinkage does exist it must vary with the different kinds of soil and other factors, so that a uniform allowance of 10 (or any other) per cent cannot truly represent actual conditions. The best that can be said of such a method is that it might provide an average amount, but may be wide of the truth; hence the use of such a percentage cannot be conceded in the light of our present knowledge.

"On any valuation section there is usually a prevailing type of soil for which the actual behavior under various conditions can be found by means of careful experiments made upon similar soils under like conditions, and upon a scale commensurate with the importance of the matter. These experiments must be made upon a sufficient number of soils and with conditions of placing enough varied to render the results thus obtained finally conclusive. Before this Commission can properly make allowances for shrinkage its existence must thus be conclusively shown, and upon the carriers must rest the burden of proof, since they are the parties at interest. So strong is the conflict between the assumption that such shrinkage exists and common reasoning to the contrary that nothing other than such extended and conclusive experiments will probably settle the issue. So complete is the lack of reliable experiments concerning shrinkage that it seems those made by Ellwood Morris three-quarters of a century ago, when railroad construction was yet in its infancy, constitute the sole foundation upon which rests the whole theory of shrinkage."

How to Improve Maintenance of Way Methods

Mr. A. M. Burt, Assistant Director, Division of Operation, U. S. Railway Administration, in a recent issue of the U. S. R. A. Bulletin, makes a plea for maintenance men to obtain measures of work done in maintenance of way work, which he says are chiefly conspicuous by their absence. These measures of work, it is believed, are very desirable, in order to compare the efficiency of different men, and to compare the efficiency of the same man at different times. On many roads a budget system is in use, but no matter how well such a system is carried out it does not supply the measure of work done. The supervisor knows that he has been allowed a certain amount and believes that he has spent this amount judiciously, but he has no way of knowing definitely whether he has accomplished more or less than the supervisor on an adjoining district or of knowing whether he is making an improvement or the reverse as compared with his past record.

There is nothing that stimulates thought and initiative to such an extent as a little competition with one's neighbor. It puts an element of sport into the job and not only helps work, but is a most developing condition for the individual. It is realized that the character of maintenance work makes it especially difficult to establish measures of work accomplished such as are in common use in connection with transportation matters, but there is apparently a tendency to magnify the difficulties of the subject and to assume the attitude, "What's the use? It can't be done." It surely must and will be done in a much larger measure than it is being done at present, and, if it is to be well done, the practical maintenance men must take an active interest in the subject and do their bit in solving the problem. When we have done anything in one way for years we all are apt to consider that way as being the only right one and to consider the subject is a closed book. This, in a measure, is the present attitude of mind, but we have got to shake ourselves loose from such an attitude if progress is to be made.

Mr. Burt offers the following by way of suggestion:

1. Better facilities should be provided for the exchange of ideas. Local roadmasters' and supervisors' associations are most helpful if discussions are kept along general lines and away from matters having only a narrow and local interest. The time of the men away from their routine work is well spent. There is less experience with foremen's associations, but apparently considerable benefit might be derived from them.

2. Attendance at national maintenance of way meetings should be actively encouraged and liberal allowances should be made for the expenses of men attending such meetings. The men always bring back ideas and inspirations that result in more efficient work.

3. The question of getting a more general dissemination of ideas and information through publications should be considered. There should be a more general use of the maintenance of way periodicals.

4. The problem should be worked out from the inside and by the talent already on the individual railroads. There is plenty of such talent, and, by encouraging the local men to work out the problems, morale will be improved. They can do the work much better than it can possibly be done by any so-called efficiency expert from the outside. In doing this each man should be given proper credit for his ideas and his part in the work.

Dynamite Extinguishes Gas Well Fire

After burning for 10 days a gas well fire, said to be the largest ever encountered in the oil producing industry, was extinguished by the use of dynamite. The fire started in a well being drilled in Midway oil fields near Taft, Col., by the Standard Oil Co. The well was at a depth of 2,135 ft. in 10-in. casing, when a supposed water sand was encountered. To test this sand for water, the mud in the well was bailed down to relieve pressure, and to allow any water present to accumulate in the well. During the course of bailing, at 11 P. M., July 26, 1919, the well blew out under tremendous pressure and a flow of gas, estimated at 180,000,000 cu. ft. per 24 hours, began.

Burning Gas Well That Was Extinguished With Explosives.

The drilling crew attempted to get the well under control by closing the 12½ in. gate valve with which the casing was equipped but the shale and sand carried by the stream of gas cut out the seat of the valve while the gate was being closed, and the well continued to flow. Two hours after the flow began, the friction caused by shale and sand traveling at a great velocity had produced a red hot heat on the casing, and the gas, igniting, burst into a column of fire, gushing 300 ft. skyward. Its maximum width of about 50 ft. was reached after the flame traveled about 100 ft. upward. The gas emerged from the casing with such force that for a distance of 12 ft. about the casing there was no flame. On July 27 the casing above ground blew off, and the well began to crater, allowing the flame to draw down to the ground level.

All attempts to extinguish the blaze by means of water and steam failed. In one of these attempts 20 boilers and 11 rotary pumps were used in throwing steam, water, mud and carbon tetrachloride on the flame. Bombarding the well with field howitzers also was considered, but army officers reported that portable artillery was too small in calibre to accomplish the task.

A plan, suggested by Ford Alexander, an oil well blaster, was then tried. This consisted essentially in suspending a package of blasting gelatin upon cables in such a manner that the package could be safely brought to the edge of the fire at a height of about 40 ft. above the ground.

Two derricks approximately 40 ft. high were built on either side of the burning well and so far away that the heat would not destroy them. A 9-16 in. steel cable was attached to the top of one of them, then laid around the well outside of the terrific heat zone, to the other derrick where it was run through a pulley at the top and the end attached to the drum of a small winding engine underneath. The explosives, 150 lb. of Giant blasting gelatin, bound in one package and covered with heavy sheetings of asbestos, were securely attached to this cable at the same distance away from the first derrick as was the burning well. The explosives, before being made up into this package had been primed electrically. When this was done, the engine under the second derrick began drawing the cable taut which pulled the explosives toward the well and at the same time hoisted them. When they had reached the proper spot, they were exploded electrically. It is unnecessary to state that this had to be done very quickly so as to bring the explosive charge to the necessary point before they were ignited or exploded by the heat from the burning well.

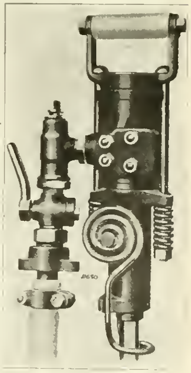
With a stream of water from a 3-in. hose playing upon him, and upon the protecting screen behind which he was working and upon the ground over which he was advancing, Mr. Alexander worked forward with the explosive package for the purpose of being sure that the package was in the position he wanted it at the moment of explosion.

As the package drew near the column of gushing fire the suction of rushing air drew it to the flame, and as it reached the outer edge of the fire Mr. Alexander exploded the package. At the moment he exploded it he was within 200 ft. of the explosion but states that he neither heard nor felt anything.

Eye witnesses at a greater distance state that when the package exploded, the gas well fire was divided into three sections. The section at the point of explosion was moved bodily away from the column of gas in a horizontal direction, the upper section was blown upward and beyond danger of re-ignition of the gas column, while the lower section was snuffed out very much as a candle is snuffed out, the flow of gas being temporarily checked.

A 21½ Lb. Self-Rotated Hammer Drill

A light self-rotating hammer drill, specially adapted for work in locations and positions not accessible to heavier machines has been developed and placed on the market by the Ingersoll-Rand Co., New York City. The drill weighs 21½ lb., and is known as the Bar-33 "Jackhamer."



Bar-33 "Jackhamer."

The manufacturer recommends this light drill for bench work in soft lime stone quarries; for trimming in metal and coal mines, and for pop hole work in quarries and open pit mines. In addition to the above the machine may be conveniently used for drilling holes in concrete and masonry foundations. This type of "Jackhamer" is not recommended for drilling deep holes or for use in hard rock, but for drilling where a machine of extreme light weight is necessary.

The Bar-33 is the fourth type of "Jackhamer" manufactured by the Ingersoll-Rand Co. Machines of this type are now available varying in weights: 21½, 35, 41, and 70 lb.

Recommended Street Railway Improvements for Toledo.—The city engineer of Toledo, O., has submitted a report recommending changes in the Toledo street railway system. The plan involves abandonment of 19.04 miles of tracks and construction of 16.04 miles of lines, the changes being calculated to eliminate costly duplication of service in same areas, and to provide service in other portions of the city, so that, except in sparsely built-up neighborhoods, residents would not be compelled to walk more than 1,200 ft. to the nearest car line.

Railway Operation in 1919 by U.S. Railroad Administration

Continuance of many reforms in railroad operation inaugurated under the Federal control of the lines was recommended in the annual report for 1919 of W. T. Tyler, Director Division of Operation of the United States Railroad Administration, submitted to Director General Walker D. Hines and made public on Feb. 10.

Centralized Control of Cars.—A factor in the successful handling of the heavy business in 1919 had been the centralized control of the cars which has made it possible to relocate equipment without reference to initials in accordance with the demands of commerce. This is another feature which should be continued under proper limitations under a central organization of the railroads themselves.

The common use of cars was not only successful with reference to box, stock, and flat cars, but it was particularly so in the case of refrigerator cars, which since July 1, 1918, have been handled by the Car Service Section through a branch office located at Chicago. Tank cars have also been handled through this agency.

In its formal recommendations as to the handling of the car supply, the report said:

"The experience of the Car Service Section during the past two years has made it quite clear that there should be continued some uniformity of method of car control and distribution as between portions of the country, railroads, stations and shippers. The result of the two years' work has produced, among other things, uniform rules to govern the distribution of coal cars and grain cars, and this establishes practical uniformity with respect to the car supply for the two most important commodities handled by the railroads. There is, however, room for improvement along these lines with respect to other of the important tonnage-producing articles.

"It is therefore recommended—

"That the railroads continue the work of establishing uniformity in rules governing car supply for the various important commodities handled.

"That the campaign which has been continued now for two years under varying circumstances for the more effective utilization of equipment by heavier loading be continued.

"That every effort be made to continue and extend the pooling of lake and tidewater coal; the railroads maintaining the necessary organizations at all times to handle traffic so pooled.

"That arrangements be made to set up, at least in skeletonized form, the organization necessary to control the movement of traffic to and via ports whenever traffic conditions warrent by the placing of embargoes and the issuance of permits."

Conditions which Railroads Must Meet in Near Future.—Looking forward to the conditions which the railroads must meet in the near future, the report said:

"The locomotives of the country are in better condition as a whole than they have ever been before during a period of very heavy business, and while they number above 65,000, an adequate program for new power should be adopted at an early date in order to take care of the commerce which there are abundant reasons for believing must be handled by the railroads in the months and years which lie just ahead.

"There have been completed in the first nine months of 1919 442 locomotives which were ordered prior to Federal control, 989 locomotives built to standardized design prepared by the United States Railroad Administration, and 103 locomotives constructed in railroad shops, making a total of 1,534 new locomotives placed in service during the first nine months of the current year.

"The program in repairing freight cars, with the new cars added has resulted in rapidly making available an increased number of cars for the handling of the business of the fall and winter, but these cars will not be sufficient for the requirements of next year, unless all signs fail, and a comprehensive car-building program should be adopted by the railroads as early as practicable.

"Inadequate facilities for making repairs to locomotives and cars which were emphasized by railroads receiving heavier power during the war wihtout proportionate increases in facilities made maintenance of equipment a difficult operation. Wherever possible terminal facilities were consolidated to promote efficiency as well as to reduce overhead expenses. This permitted us to utilize the best of facilities for the benefit of all the roads: 844 terminals have been so consolidated during Federal operation.

"From the beginning the mechanical department of the Division of Operation has diligently endeavored to maintain the equipment without any idea that economies should or could be realized by reducing maintenance which the equipment ought to receive, but with the thought that the fullest possible measure of maintenance should be given, trying through greater vigilance to get more maintenance per dollar of money expended than would be obtained if such vigilance were lacking."

Standardization of Locomotives and Cars.—Discussing standardization of locomotives and freight cars, Director Tyler reported:

"Experience with these standardized locomotives and cars has shown them to be of exceptionally good design and construction. The locomotives, wherever tested against similar locomotives built to individual designs, have shown superiority in the matter of efficiency and economy in operation, and while it is yet too early to give definite figures with respect to maintenance, it is being demonstrated that the standardized fittings and design of parts will reduce maintenance costs."

The co-ordination of the terminals was recommended by Director Tyler as a continuing policy for the railroads. He said:

"That the Railroad Administration has been justified in the consolidation of terminals is shown by the results obtained from this operation. The terminals have not only been operated more economically but more efficiently, congestions have been lessened or avoided, terminal delays reduced, car supply increased by the saving of cars from less-carload service by consolidating those formerly loaded in duplicate for the same destinations, empty car mileage avoided, and the interchange of cars with connections greatly facilitated.

"The benefits from the unification of terminals are so many and the improvement of the service so marked that it is to be hoped that whatever the status of the railroads, there may be serious consideration given to each case of consolidation, unification, or co-ordination before it is discontinued.

"This should be done, also, in each case of the use of single-track parallel lines as double track and the co-ordination or unification of water terminals, etc., so that the plans worked out under Federal control which have resulted in greater transportation efficiency may be retained under private operation where it is practicable to do so."

Maintenance of Way Work.—In discussing maintenance of way work, Director Tyler said:

"In handling the maintenance of way work one of the most important items that had to be met was the increasing cost of labor and material. As expenditures for maintenance of way and structures represent about one-sixth of the total operating expenses, naturally this phase of railroad administration has been prominent during the year and a consistent effort has been made to increase efficiency. Regional directors have held frequent conferences on the subject with their Federal managers, who in turn have gone into it with their subordinates with a view to stimulating interest in the effort to improve supervision over maintenance matters and to increase the efficiency of the workmen. It is felt that important progress has been made and that the work done in this direction will be a benefit to the railroads for the future."

Breaking In New Wire Rope.—When a new wire rope is put into use, and this applies to all kinds of equipment and purposes, it should be run for a short while without a load in order to let it get adjusted or "set" to the conditions. It is also advisable to go further and reduce the normal load for a short while when breaking in a new rope. The time lost in doing this, states Leschen's Hercules, will be well paid for by the extra rope service obtained.

San Francisco Engineers Endorse Hoover for President.—Joint Council of Engineers of San Francisco, representing 2,000 engineers in the Bay District, has adopted resolutions indorsing Herbert C. Hoover, for president, and has invited the engineering bodies of the United States to join with it in forming an organization to further Mr. Hoover's election.

Accident Prevention in Locomotive Crane Operation*

By CHESTER C. RAUSCH,
Assistant Director, Safety Institute of America.

One of the main sources of hazard consists in the failure to keep the road-bed over which the crane must travel in the best condition. Frequently, in an effort at economy, light weight or partly decayed sleepers and second-hand, defective or light rails have been used, resulting in an inconvenient and unsafe road-bed. The failure to keep the road-bed properly tamped and drained allows it to settle and become uneven so that the crane does not travel steadily and is far more liable to overturn. The use of improper frogs, cross-overs and switches, and the failure to keep them in repair, increase this hazard. Such a road-bed throws numerous strains into the structure of a moving crane by the swinging motion imparted to the load suspended from the boom. This condition sometimes becomes aggravated to a point where collision of the suspended objects may occur with other railroad property or with structures adjacent to the track. When track-ways are too near buildings, especially on curves, the entire attention of the engineer is often required to prevent collision with the buildings. These things distract the operator's attention so that collisions with pedestrians, trucks and teams are more apt to occur.

Another difficulty is the inability of the operator to maintain a clear view both ahead and behind his crane while traveling. Inability to see toward the rear frequently results in people being injured when the crane is turned on its table while moving forward or in running over people or objects when running backward. Reflecting mirrors, similar to those used on automobiles, tend to eliminate this difficulty, provided the mirrors are adjusted carefully and are of sufficient size. In some cranes small windows have been placed low down in the rear through which the engineer can see behind the crane. Even when alarm bells or gongs are used the engineer cannot be certain, without seeing, that the track is clear.

Whenever any crane overturns, unusual and frequently very considerable strains are placed on the structure of the crane, particularly the boiler and steam piping which, because of the internal pressure, are already seriously stressed. Engineers, even if they are fortunate enough to escape scalding or injury when the crane overturns, may be penned in and seriously burned unless the doors and windows are arranged to open outward and are provided with fasteners operating from both the inside and the outside.

Many times the original structure of the crane, particularly the boom, has been changed; lengthened to increase its range, strengthened to increase its capacity for lifting. Such changes frequently introduce strains that cause collapse and often result in death to the operator. It is a tendency that most certainly should be corrected.

If the operator of a crane, and particularly of one that has been structurally changed, is given to the performance of spectacular stunts, the limit of damage is beyond estimate. Speeding the crane along the track, rotating it upon its turn-table at such speeds that the load is swung far beyond a point directly below the end of the boom, and the dropping of the load from considerable heights and stopping it just before it reaches the ground, are performances which the cranes were not constructed to stand even considering all factors of safety used in their design. The combination of two or more of these performances at the same time may introduce strains great enough to overturn the crane, to destroy its structure, and to injure not only the crane but many structures adjacent to it. Where the crane is elevated upon a trestle the hazard is greatly increased.

Many operators overload cranes and take a chance that the crane can handle the load. This tendency is fostered by the fact that the crane is never under the observation of a single foreman but moves from place to place in charge of its operator. While such acts are, of course, matters of discipline, there are several devices which have been attached to cranes to indicate when the crane is at the point of overturning and to give audible warning beforehand. The best devices of this sort are placed in the cab of the engineer and are frequently supplemented by an indicator placed on the boom which shows, by means of a pointer, the safe load that may be picked up for any given boom elevation. This indicator may also indicate safe overhead clearances for the boom. The use of the tables of safe boom elevations for given loads, frequently placed on plates attached to the frame of the crane or in the cab, cannot be depended upon because they require the exercise of the element of personal estimation of conditions upon the part of the operator.

Whenever cranes approach obscure corners of buildings, door openings, or other points from which traffic or individuals may issue, the engineer should be under obligation either to stop the crane or to have it in such control that a collision cannot occur.

Locomotive cranes are frequently poorly illuminated. The installation of a storage battery provides current for adequate light in the cab for firing and for illuminating the gauges and particularly for a spot light that can be thrown upon the objects handled. Very frequently a light placed on the tip of the boom, and arranged to throw its rays vertically downward, has been found of great advantage. Whenever such cranes work at night consideration should certainly be given to these points.

The work done by locomotive cranes is nearly always conducted out of doors and little attempt is made to house them or to protect them from the elements. As a result rust, with all its attendant and subtle hazards, attacks the machine in various places—the cables particularly. Proper painting should be given at frequent intervals, adequate lubrication should be provided, and the boiler should have regular inspection. Improper feed water may introduce trouble enough to put the crane out of commission.

In the operation of such cranes dependence is frequently placed upon lowering the load and swinging the boom to throw an object into a location that cannot be reached by the crane when in its ultimate safe position for such a load. The element of time is here depended upon to permit the load to swing into its final place before it can tip the crane far enough to cause it to overturn or leave the rails. Any failure of judgment on the part of the operator is fatal.

Another pernicious tendency is sometimes revealed when the crane is derailed and a leverage action is created by attaching the boom to the track ahead and by the application of power causing it to lift the rear end of the crane so that it may be swung again to the rails. This is done with the boom in an almost horizontal position and has destroyed cranes by introducing the severest strains to which a crane could be subjected. The housing of the hoisting mechanism and the anchorages of the turn-table are very often torn apart in this manner.

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*From a paper presented at the Eighth Annual Safety Congress of the National Safety Council.

Dynamite As Aid in Digging Pole Holes in Winter

Pole and post hole digging in winter by ordinary methods is difficult. Post hole excavators cannot be used, nor can picks be employed except for the first few inches of frozen soil. Low freezing dynamite, suitable for use in the open, in winter, is becoming popular with hole crews. It takes much less time and labor merely to put down a 2-in. bore hole in frozen earth than to dig a 12 or 15-ft. hole. The stick or half stick of dynamite is pushed to the bottom of the bore hole, tamped in (sometimes with snow) and fired with cap and fuse. It is then a quick and easy operation, after the soil has been broken up and loosened by the shot, to dig out the hole to required size. There is little danger of unduly loosening up the sides of the holes, when the ground is frozen. But even if an occasional hole is broken out a little too wide, it can usually be depended upon to freeze up solid again over night.

Delivering Sand to Locomotives by Compressed Air.—A compressed air system of delivering sand to the locomotives of the Belt Railroad of San Francisco has recently been placed in operation by the California State Board of Harbor Commissioners. The sand is shoveled into a steel drum and forced upward through a delivery pipe at 45 lb. pressure. It is conveyed to the sand box of the locomotive by a telescoped and jointed pipe.

The Economic Disposal of Waste Material by Dump Cars

A paper on this subject was recently presented before the Railway Club of Pittsburgh by Major H. L. Beach in which examples were given of economies effected by the use of specially constructed side-dumping railway cars for the rapid handling of practically any loose or granular material. Such cars have a capacity of 40 to 45 cu. yd., or 50 tons. Some of the examples given by Major Beach are taken from his paper as follows:

The Lehigh Coal & Navigation Co. was one of the first to recognize the value of efficient dumping equipment, and in order to get the best results, changed several miles of narrow gage track to standard gage, built a couple of railroad bridges, purchased standard gage locomotives, and lowered the grade of their tracks several feet so they could use the largest dump cars obtainable to dispose of the rock waste from hard coal mines without labor on the rock dump. They have since the first installation bought several installments of equipment of a similar nature for other mines.

The quantity of rock handled in this instance is large. The mines feeding three breaker and washer plants waste between 10,000 and 12,000 tons every day. This rock is entirely too large to handle in hopper cars pieces often being several feet across in any dimension chosen for measurement, and quite comparable to large slag sculls from open hearth furnaces. At one operation they have three rock trains working. Each train consists of a locomotive and two cars, and each train makes between 25 and 30 trips every day. The cars carry 50 tons of rock each which means that between 7,500 and 9,000 tons of rock are dumped every day. The entire labor force for this work consists of two men on each train, a foreman and nine laborers keeping the track in shape on the dump, and a couple of men on the loading chutes. Figuring $4.00 per day per man, or $72.00 for the lot, the labor cost on 7,500 tons dumped is less than 1 ct. per ton.

The Central Steel Co. purchased one dump car for disposing of its open hearth slag and found that they had a direct labor-saving equal to the cost of the car every 100 days. This is possibly exceptional as the haul was measured in yards and they dump the car several times a day using a shifting locomotive that would otherwise have been partially idle waiting for ingot cars to be loaded or unloaded.

The Baldwin Locomotive Works at its Eddystone plant put six dump cars into service removing a large clay bank in the middle of its plant. They increased the rate of removal from 250 cu. yd. a day to 400 and reduced their direct cost from 90 ct. per cubic yard paid to a contractor to 16 ct. paid in renting a small steam-shovel, and directly against their cost of a locomotive and crew.

In the spring of 1918 the Ordnance Department, United States Army, desired to raise the level of Neville Island for the purpose of building a large munition plant. The work was carried on under the direction of the United States Steel Corporation, Ordnance Department. The material for the fill was waste from the steel plants, largely granulated slag. Some 60 car loads were delivered daily to the island in hoppers and gondolas. That meant that it was necessary to unload all this material each day. Within about two days every track in sight was filled with cars of slag awaiting disposal.

The usual gang required to unload a hopper is six men, and they can unload an average of two cars a day. To unload 60 hoppers, therefore, not only required 180 men, but a dump track long enough to accommodate 30 cars at one time. Since track must be shifted occasionally, it is readily seen that to keep the operation moving all the time about 250 laborers were required, and the face of the dump must be at least ½ mile long, or longer than the width of the island. The officials found it impossible to make any headway at all under those conditions and therefore looked elsewhere for relief.

Twenty dump cars were purchased and operated in two trains. The hoppers were run through the steel plant car dumper and discharged into the dump cars. This was found not to be entirely satisfactory, and a wooden trestle was built containing bins beneath the track. The hoppers were to be dumped in the manner for which they were designed, i. e., into the bins. The dump cars would run on a lower grade level and load directly from the bins. This was just completed at the time of signing the armistice.

With the car dumper, however, a train of dump cars would run to the dump and return in about 40 minutes. One train was being loaded while the other was going out and returning. With this arrangement the work was carried on as fast as labor could advance the tracks on the edge of the fill being made. Remember this was not a proposition of cost, but a proposition of getting the work done, and done as soon as possible.

Municipal Roads Are Not Independent of Economic Laws

Editorial in Electric Railway Journal.

Delegates to the conference of the Public Ownership League of America, held recently in Chicago, appeared to be a well-satisfied aggregation as they adjourned after adopting resolutions in support of the principles to which they are all committed. They had heard their leaders tell of the growth of sentiment in favor of public ownership, and they seemed happy in the thought that the dawn of a new era was at hand.

Two papers were read at that conference in which statements were made which tended to show that even municipal ownership cannot accomplish the impossible—that is, pay all the costs of street railway service out of a 5-cent fare. One of these was made by the city engineer of San Francisco who had much to do with the construction of the municipal line, and the other by the chief executive of the Seattle property. Of these two roads, the former is one of the oldest, and the latter is the largest of our municipal railway undertakings.

Mr. O'Shaughnessy of San Francisco explained that it had been the custom to set aside 18 per cent of the gross receipts to cover depreciation and damages. He admitted that in order to meet the July expenses it was necessary to borrow money from this fund, and he did not know whether this practice would be continued He also conceded that "it is much more desirable that the returns to the corporation or to the municipality be sufficiently high to insure first-class service rather than to retain a low fare and allow the service to deteriorate."

Mr. Murphine of Seattle declared that no amount had been set aside for depreciation of the municipal railway—that the authorities believed rather in spending this fund than in allowing it to accumulate. He did not think it a proper railway expense under city ownership and management to care for and maintain that portion of the street covered by tracks, and this is not being done in San Francisco. This official also admitted that municipal ownership alone would not make a nickel fare go as far as formerly, saying that it would have to be accompanied by relief from franchise obligations and by economies in operation. "Relief from all franchise obligations is imperative," said he, "and under public ownership and management there can be no just reason why any portion of the nickel fare should be taken to pay other than legitimate railway expenses."

A Massachusetts advocate of public ownership recently said: "Even if public ownership be adopted we shall have to utilize the service of human beings." He might just as truly have said that under public ownership a nickel fare would not be found any more elastic nor would it have lower expenses to meet either for labor or materials.

These M. O. "fans" are inclined to be very frank among themselves. They admit that they cannot work miracles. But they do boast that they can furnish local transportation for a 5-cent fare "if"—Ah, there's the answer!—if they are relieved of non-transportation charges such as paving, taxes, etc.—burdens which they have been refusing for years to lift from the shoulders of those who have been striving to make a success of the 5-cent fare under private operation.

As a recent Massachusetts report stated: "Public ownership will not change these facts. All these amounts must be met either by the car rider or by the taxpayer, whatever be the system of ownership or management adopted. Facts exist even when concealed by the magic mist of public ownership."

Wages of Railway Employes

Employes of the Class 1 railroads under Federal control numbered 1,894,287 on July 1, 1919, according to a table issued by the Federal Railroad Administration. The average monthly compensation per employe on the above date was $119.38, with an increase of 42.7 per cent over the compensation paid during the calendar year 1917. The table follows:

The only government-built railroad—that across the Isthmus of Panama—cost $221,052 per mile. The only two recently built railroads in the United States are the Virginian, built by H. H. Rogers, which cost exclusive of equipment $151,000 per mile, with labor at from $1.35 to $1.75 per day and all machinery, fuel, rails, supplies at its door, and the Milwaukee line to Puget Sound, which is estimated as having cost $130,000 per mile exclusive of equipment.

Class of employe—	Number of employes, July, 1919.	Average monthly compensation per employe. July, 1919.	Dec., 1917.	Cal. yr. 1917.	Per cent of increase July, 1919, over Dec., 1917.	Monthly aver. for calendar yr. 1917.
General officers	7,432	$359.60	$390.26	$379.84	*7.9	*5.3
Division officers	12,511	245.47	178.23	174.92	37.7	40.3
Clerks (except No. 37)	216,764	111.83	79.58	77.63	40.5	44.1
Messengers and attendants	10,122	70.44	44.26	42.86	59.2	64.3
Assistant engineers and draftsmen	10,370	138.96	104.74	95.40	32.7	45.7
M. W. & S. foremen (excluding Nos. 10 and 28)	[illegible]	142.68	106.90	99.74	33.5	43.1
Section foremen	40,899	108.18	78.21	73.84	38.3	46.5
General foremen, M. E. department	[illegible]	259.51	155.69	138.37	91.3	87.5
Gang and other foremen, M. E. department	23,592	195.41	122.26	112.64	59.8	73.5
Machinists	59,067	142.18	126.11	116.20	12.7	22.4
Boiler makers	18,413	147.74	127.67	118.76	15.7	24.4
Blacksmiths	9,898	136.35	110.92	104.84	22.9	30.1
Masons and bricklayers	1,186	115.37	80.88	77.64	42.6	48.6
Structural iron workers	673	131.58	86.17	84.53	52.7	55.7
Carpenters	50,854	117.30	81.70	78.35	43.6	49.7
Painters and upholsterers	12,632	118.64	85.64	79.22	38.1	49.8
Electricians	13,200	143.97	93.59	85.94	53.8	67.7
Air brake men	7,781	132.37	100.59	90.53	31.6	46.2
Car inspectors	24,258	145.71	106.03	95.02	37.4	53.3
Car repairers	80,417	123.33	87.77	82.81	40.5	48.9
Other skilled laborers	56,307	132.15	95.00	88.77	39.1	48.9
Mechanics' helpers and apprentices	107,263	95.13	74.17	68.52	28.3	38.8
Section men	286,300	77.80	53.48	50.09	45.5	55.3
Other unskilled laborers	118,932	87.60	63.77	57.94	37.4	51.2
Foremen of construction gangs and work trains	1,910	128.04	101.71	85.91	25.9	49.0
Other men in construction gangs and work trains	30,306	81.84	59.24	51.95	38.1	57.5
Traveling agents and solicitors	1,355	177.60	154.29	136.82	15.1	29.8
Employes in outside agencies	927	140.85	119.72	88.85	17.6	58.5
Other traffic employes	426	165.40	125.16	110.83	32.2	49.2
Train dispatchers and directors	5,413	228.13	155.66	150.13	46.6	52.0
Telegraphers, telephoners and block operators	20,859	129.46	80.59	76.39	60.6	69.5
Telegraphers and telephoners operating interlockers	8,243	131.43	85.48	79.71	53.8	64.9
Levermen (nontelegraphers)	3,926	125.28	74.24	70.99	68.8	76.5
Telegraphers' clerks	11,362	129.23	80.23	74.35	61.1	73.8
Agent telegraphers	19,065	139.64	87.51	79.06	59.6	76.6
Station agents (non-telegraphers)	13.898	139.50	92.36	86.52	51.0	61.2
Station masters and assistants	605	161.01	109.07	107.66	47.6	49.6
Station service employes (except Nos. 5, 6, 37, 38, 39, 40, 66)	115,255	93.52	64.75	59.14	44.4	58.1
Yardmasters	3,905	247.39	157.98	150.19	56.6	64.7
Yardmasters' assistants (not yard clerks)	3,122	216.17	136.02	142.12	58.9	52.1
Yard engineers and motormen	19.153	175.14	148.62	149.16	17.8	17.4
Yard firemen and helpers	19,559	126.03	92.15	91.10	36.8	38.3
Yard conductors (or foremen)	18,785	159.09	129.68	132.03	22.7	20.5
Yard brakemen (switchmen or helpers)	47,815	141.51	111.85	110.55	26.5	28.0
Yard switch tenders	6.129	120.76	75.44	70.52	60.1	71.2
Other yard employes	4,705	92.12	60.70	55.54	51.8	65.9
Hostlers	10,687	132.73	110.80	103.73	19.8	28.0
Engine house men	68,685	104.55	76.83	69.56	36.1	50.3
Road freight engineers, motormen	30.405	223.86	190.09	175.55	17.8	27.5
Road freight firemen and helpers	31,608	156.72	114.20	106.11	37.2	47.7
Road freight conductors	24,501	194.73	163.90	154.50	18.8	26.0
Road freight brakemen, flagmen	60,525	145.70	106.52	100.13	36.8	45.5
Road passenger engineers and motormen	12,761	256.41	201.50	186.02	27.3	37.8
Road passenger firemen, helpers	12,413	184.19	124.85	112.79	47.5	63.3
Road passenger conductors	10,649	226.20	171.47	163.82	31.9	38.1
Road passenger baggagemen	5,669	162.33	102.96	97.92	57.7	65.8
Road passenger brakemen, flagmen	15,636	151.43	98.97	91.09	53.0	66.2
Other road train employes	3,415	120.09	74.72	68.05	60.7	76.5
Crossing flagmen and gatemen	23,069	78.68	48.29	44.59	62.9	76.5
Drawbridge operators	1,669	98.75	69.94	63.43	41.2	55.7
Floating equipment employes	9,288	135.66	92.57	77.36	46.5	75.4
Policemen and watchmen	11,541	117.79	78.44	74.66	50.2	57.8
Other transportation employes	5,470	97.52	77.82	70.41	25.3	38.5
All other employes	20,876	82.91	58.29	55.23	42.2	50.1
Totals	1,894,287	119.38	89.83	83.64	32.9	42.7

*Decrease.

Present Status of Alaskan Railroad Construction

The project of building some 470 miles of railroad in Alaska, begun a few years ago by the U. S. Government, has been progressing very satisfactorily, according to the annual report of the Hon. Franklin K. Lane, Secretary of the Interior, under whose direction the work is being done. The road is now more than two-thirds built and Congress, after making quite an exhaustive investigation into the project, has authorized additional appropriation sufficient for its completion. Secretary Lane states that the best estimate that can be made today as to the newly constructed line is that it has cost between $70,000 and $80,000 per main-line mile, or between $60,000 and $70,000 per mile of track. This cost per mile includes the building of the most difficult and expensive stretch of line along the entire route from Seward to Fairbanks—that running along Turnagain Arm, which is sheer rock rising precipitously from the sea for nearly 30 miles. There are miles of this road which have cost $200,000 per mile. Even to blast a mule trail in one portion of this route cost $25,000 a mile.

The Alaskan work has been conducted with its main base at Anchorage, which is at the head of Cook's Inlet. This point was chosen as the nearest point from which to construct a railroad into the Matanuska coal fields. That was the primary objective of the railroad, to get at the Matanuska coal. From Anchorage it was also intended to drive farther north through the Susitna Valley and across Broad Pass, and to the south along Turnagain Arm toward the Alaska Northern track. To secure coal for Alaska was the first need. So in addition to Anchorage as a base, one was also started at Nenana on the Tanana river from which to reach the Nenana coal fields lying to the south. If these two fields were open, one would supply the coast of Alaska and one the interior. This program has been acted upon, with the result that the Matanuska field is open to tidewater with a down grade road all the way. The Nenana road has been pushed far enough south to touch a coal mine near the track, which may obviate the immediate necessity for reaching into the Nenana field proper.

Fifty-five thousand three hundred and ninety tons of coal were mined at the two government mines in the Matanuska field during the year ending June 30, 1919.

The Legislative Act for Licensing Land Surveyors in Illinois

In June, 1919, the legislature of the State of Illinois passed an act in relation to land surveyors, the important parts of which are as given below:

"On and after Jan. 1, 1920, it shall be unlawful for any person to practice or attempt to practice land surveying in counties having a population of 250,000 or more, without a certificate of registration as a registered land surveyor issued by a board of land surveyors" as described below.

County surveyors, employes of city, county, the state, or the United States, in the discharge of their official duties are exempt from the provisions of the act.

The definition of the words "land surveyor" shall, for the purposes of this act, be held to be a person who for a consideration establishes one or more corners or boundaries of any tract or lot of land and executes and issues plats thereof signed by himself as a surveyor.

Within thirty days after the taking effect of this act, the county judge of every county having a population of 250,000 or more shall appoint a board of examiners of land surveyors, to consist of three persons, one of whom shall be the County Recorder and two of whom shall be land surveyors of recognized ability and standing. The appointment of the two land surveyors of this board shall be for one and two years respectively. Thereafter their appointment shall be for two years. The County Recorder shall be the president of the said board. The members of the board shall meet within ten days after their appointments and organize by the election of one of the land surveyors as secretary and treasurer.

Any person who shall make application for registration before the first day of January, 1920, and shall prove to the satisfaction of the said board that he was established in the surveying business at the time of the taking effect of this act, or has been actively engaged in the practice of land surveying, as a surveyor, for a period of not less than five years shall, upon the payment of a fee of $25.00 to the said board, be registered without examination and shall receive in testimony thereof a certificate signed by the president and secretary of the board: Provided, that in case of failure or neglect of any such person to register before the first day of January, 1920, as herein provided, such person shall be deemed to have waived his right of registration under this section, and in order to be registered shall comply with the requirements for registration by examination.

Any person not entitled to register as aforesaid, who shall furnish the said board with satisfactory proof that he is twenty-one years of age or over, and of good moral character, and that he has had at least four years' experience and training as a land surveyor shall, upon payment of a fee of $25.00, be examined as provided herein, and if qualified shall be registered and shall receive in testimony thereof a certificate of registration signed by the president and secretary of the board.

Every person to whom a certificate of registration is granted under the provisions of this act, shall display the same in a conspicuous place in his office or place of business or employment. Any person violating the provisions of this section shall, upon conviction thereof, be punished by a fine of $50.00.

The said board shall hold examinations at such times and places as it may determine. All examinations shall be in the English language, and shall be of such a character as to determine the fitness of the applicant to practice land surveying. Each applicant shall be examined as to his knowledge of the statutes of the United States and of the State of Illinois relating to surveying, sub-divisions of land, practical surveying, the use and adjustment of surveying instruments, and of mathematics as applied to land surveying. Any candidate who shall fail to pass a satisfactory examination shall be entitled to a second examination without further charge, provided such second examination is taken in not less than three months nor more than twelve months thereafter.

Every registered land surveyor who continues in the active practice of his profession shall, annually during the month of January, renew his certificate of registration by the payment of $2.00 to the said board of land surveyors. All certificates of registration which are not renewed during the month of January of each year shall become null and void, but may be restored upon the payment of the yearly fee or fees and an additional sum of Ten Dollars ($10.00).

Every registered land surveyor shall have a seal, the impression of which must contain the name of the land surveyor, his place of business, and the words "Illinois Registered Land Surveyor," with which he shall stamp all documents issued by him as a land surveyor.

The Board may either refuse to issue, or may refuse to renew, or may suspend, or may revoke, any certificate of registration for any one, or any combination of the following causes:

(a) The obtaining of, or an attempt to obtain a certificate of registration, or the renewal thereof, or practice in the profession, or money, or any other thing of value, by fraudulent representation, or the perpetration of fraud in the practice of land surveying;

(b) Gross incompetency or carelessness;

(c) The affixing of a registered land surveyor's seal to any documents which have not been prepared by a registered land surveyor.

The Board may neither refuse to issue, refuse to renew, nor suspend, nor revoke any certificate of registration, however, for any of these causes, unless the person accused has been given at least twenty days' notice, in writing, of the charge against him, and a public hearing by the board of examiners of land surveyors.

Each of the following acts constitutes a misdemeanor, punishable upon conviction by a fine of not less than $25.00 nor more than $200.00.

(a) The practice of land surveying, or an attempt to practice land surveying, without a certificate of registration as a registered land surveyor;

(b) The affixing of a registered land surveyor's seal to any documents which have not been prepared by a registered land surveyor.

The board of examiners of land surveyors may adopt reasonable rules and regulations relating to the enforcement of the provision of this act.

The board of examiners of land surveyors shall keep a record, which shall be open to public inspection at all reasonable times, of its proceedings relating to the issuance, refusal, renewal, suspension and revocation of certificates of registration. This record shall also contain the name, number, place of business and residence, and the date and number of the certificate of registration of each registered land surveyor in this state.

Out of the funds collected as examination fees and otherwise, the board of examiners shall first pay all the expenses of carrying out this act, including stationery, postage, clerk hire and traveling expenses incurred in the discharge of their official duties, and out of any remaining funds a salary of not more than $10 per day to each examiner for the time actually employed in the business of the Board and in necessary travel to and from meetings. Any accumulation of funds more than $200 above the estimated expenses of the current year shall be paid into the county treasury, subject to draft thereafter for the necessary expenses of the commission, whenever such expenses shall exceed the receipts for the year.

Any Illinois licensed land surveyor may take the evidence, under oath or affirmation, of witnesses, whose evidence may be useful in establishing any part of a survey; he may take an attest by his seal acknowledgment of plats and other documents relating to real estate, in the manner provided for notaries public.

All plats and certificates thereto under the hand and seal of a licensed surveyor shall be received in evidence in all courts in this state, and shall be entitled to be recorded in the county wherein the land affected thereby lies, subject always to any statutory provisions relating to the approval, recording and filing of plats of subdivisions and dedication.

The board of examiners shall issue permits to surveyors of other states to practice within the counties of this state affected by this act when they present credentials showing that they have been admitted to practice under registration or licensed laws of their own states.

All acts or parts of acts inconsistent with the provisions of this act are hereby repealed.

Railroad Ditcher Hauls Scraper in Moving Sand from Building Lots

A drag scraper hauled by an American railroad ditcher was successfully employed in moving sand and cinders from building lots adjoining a railroad embankment at Putnam, Vt., on the New York, New Haven & Hartford R. R. A cloud burst had washed out part of the 30 ft. embankment and had spread 500 cu. yd. of sand and cinder over the lots. The owner of the lots brought action against the railroad to compel immediate removal of the material. The ditcher, equipped with a clam shell bucket, moved the material within reach of its boom. The scraper was then placed in service. The ditcher pullback line was hooked to the bail and the hoisting line clipped to the back of the scraper. The arrangement of the lines is shown in the accompanying cut, reproduced from American Ditcher Scoopings. A couple of laborers dragged the scraper back to the edge of the lot to be cleaned, a distance of 175 ft. from the ditcher. The scraper, guided by one of the laborers, was then hauled by the ditcher inside of the radius of the boom and dumped by a tug on the hoisting line. The operation was repeated until all the material had been scraped into a pile along the embankment. The scraper was then removed and the clam shell connected up again, and the material loaded onto cars.

"Close Up" of Scraper Showing Arrangement of Lines.

Perforating Timber to Assist in Creosoting

On Jan. 8, 1918, Patent No. 1,252,428 was issued to Mr. O. P. M. Goss covering a process for perforating ties and other timbers in order to be able to inject preservatives more readily into the wood fibers. The process was taken over by various Pacific coast creosoting companies and an attempt made to develop its use, especially with reference to crossties. The holders of this patent have decided to dedicate it to the public, thus relinquishing all royalty charges in the future; this being done with the idea of furthering the best interests of the Douglas fir industry in the Pacific Northwest.

Douglas fir has been a rather unsatisfactory wood to undergo treatment on account of its being non-uniform in its resistance to the penetration of preservatives, and particularly so in its heart wood. The perforating machine consists of two sets of rollers, one vertical and one horizontal, spaced the proper distance apart so as to fit the given size of tie or timber, the surface of the rollers being studded with lugs which, as the timber passes through, punch the holes in the four surfaces of the wood. The holes in ties are 1/10 in. in diameter and ¾ in. deep, and in spacing are staggered so that it is only necessary for the creosote to pass along the grain a distance of 3½ in. from each perforation, in order to give complete penetration.

Some of the railroads on the Pacific Coast have put in trial installations of ties prepared in the above manner which have been creosoted either by the pressure method or by the open tank method, and it is hoped that after a term of years it will be possible to make comparisons with ties not previously perforated. It is quite certain that the perforations assist very materially in getting the uniformity of penetration of preservative which is so much desired. A very great advantage of the perforation is in the prevention of checking, as it is found that perforated ties piled out in the open alongside other ties not so treated show a minimum of checking and evenly distributed over their surface.

In a hand book on structural timber published by the West Coast Lumberman's Association of Seattle, Wash., it is stated that as a result of tests made in Portland at the Bureau of Standards of the Department of Public Works, the perforated ties showed up as 117.4 per cent as strong as the unperforated ties in compressive strength, perpendicular to grain. These tests were made on sections 10 in. x 4½ in. x 2 ft. 6 in. Other tests on sections 7 in. x 8 in. x 30 in. showed the perforated ties as 94.7 per cent of the unperforated ties in compressive strength.

Physical Effects of Pneumatic Tools on Drill Runners

Reports are sometimes heard of the ill effects of pneumatic tools on the hands of workmen. In consequence of such reports, Dr. Francis M. Barnes, Jr., M. D., of St. Louis, Missouri, was retained by the quarry operators to make an investigation of conditions in the Bedford, Indiana, limestone region. A brief review of his report is given in the January Reports of Investigations of the U. S. Bureau of Mines.

It was found that limestone workers enjoy general good health, and are not subject to any particular diseases. They are, however, subject to a disorder of the hands, particularly on the left hand, commonly known as "white fingers." The first effect is described as a feeling of coldness and pricking, as when one's fingers are "asleep," the fingers then turn white and become numb and without feeling. If the hands are rubbed or otherwise exercised, or if the workman enters a warm room, the fingers will in a few minutes become flushed and reddened, and the abnormal feeling and appearance will pass away. It is a temporary condition, and has not been known to result in any permanent disability of the hand, nor to have been the cause of any other local or constitutional disease; in fact, there are no symptoms that seem in any way to connect it with any known disease. It is probable, however, that having once occurred the person is rendered more susceptible to its reappearance. The condition is caused by (1) mechanical irritation of the skin, (2) continued muscular contraction of a cramping nature, (3) low temperature.

Of these three factors, cold is considered to be the most important for the condition only occurs in cold weather, and, when present, warmth and increased circulation cause its disappearance. It is not to be attributed to the use of the pneumatic tool alone for it does not appear in the summer when such tools are most used, and it makes its appearance more frequently on the left hand and not on the right hand in which the hammer is held. Furthermore, the disorder also affects stone workers who use a chisel and mallet, and who do not use pneumatic tools.

It is pointed out that certain measures may be adopted which will tend to prevent the occurrence of the ailment. The chisel should by some means be kept warm while in use, and an enlargement and covering of the chisel shank would also constitute a marked improvement, making it possible to hold the chisel without cramping the hand. It is also believed that liability to this disorder would diminish if the workmen wore gloves, and discontinued the prevalent custom of blocking the exhaust outlet with the thumb or finger of the right hand, thus forcing a draft of cold air along the chisel to the fingers of the left hand.

Using Old Rail for Ties

Mr. A. G. Drury, of Cincinnati, O., writing in the Electric Railway Journal, describes the use of old rail for ties on the abutment approaches of a bridge across the Ohio River owned by an electric company. The track across the abutments had to be renewed and it was found that the old rail was entirely unfit for further use for track.

The rail was cut in 7½-ft. lengths. Through the bottom flange of the rail and on both sides of the web, two pairs of ¾-in. holes were drilled. These holes were so spaced as to be flush with the sides of the bottom flange of the new rail, when it was laid on these ties at the gage used by the street railway.

The old wood ties were removed, and the holes left by them cleaned out, the old concrete between the wood ties being left intact. The new ties made of the rail were placed in these holes and clamped to the new rail by means of blocks of flat iron ½ in. thick by 2½ in. wide by 2½ in. long, with a ¾-in. hole in the center and with a rabbet cut in one end to lap over and clamp the bottom flanges of the new rail. These clamps were held to the ties and rails by ¾-in. bolts placed with their heads under the flange of the "tie rail," the stem reaching up through the ¾-in. holes in the "tie rail" and the clamp. The nut was then screwed on from the top. After each nut was screwed down as tight as possible it was spot welded to the bolt stem, to hold it fast.

The whole track work was then concreted in the regular manner up to the proper level for the granite paving.

Upon inquiry as to the cost of the job as compared to regular construction, the bridge superintendent replied that he had gotten off considerably cheaper. All the material, including the oxy-acetylene torch, was right there on the job. The flame cut the rails in a very few minutes and, disregarding the technical advantages of specially built steel ties, this was considerably cheaper.

As to the comparative cost of wood ties construction, when the superintendent balanced the cost of this procedure with the cost of new wood ties bought in small quantities, hauled to the bridge, and the labor of moving the old rail to some place until it could be sold at scrap-iron prices, the method used was seen to have cost less.

This is a specific case where special advantages prevailed and is therefore not offered as an invariable method of cutting reconstruction costs. However, certainly many street railway companies sometimes have cases where the conditions are such that the old rail can be used to advantage in this manner.

News Letter

St. Louis Items

H. F. (Big) Riley, of Clapp, Norstrom & Riley, came to St. Louis to look over the mule market. Don't know whether he invested in any mules or not, as Riley figured prices too high, and hadn't made up his mind when the writer saw him last.

Harrington Bros. are scouting around for some team work. No job too big for them. Their address is 3913 Flad avenue, St. Louis, Mo.

The physical property of the Southern Traction Co. of Illinois was turned over to Charles B. Fox, 26th street and Trendley avenue, East St. Louis, Ill. Fox said that the first step to be taken will be to re-tie the line, his engineers having informed him that such work is necessary to place the road in condition for service. The road has a number of good coal mines on its lines, which will aid greatly in solving the coal problem for large industries.

M. L. Windham is sticking close to Centralia, Ill. Doing nothing right now.

Brogan & Robinson have started a drag line on their state road job near Troy, Ill.

O. B. Avery, local representative of the Western Wheel Scraper Co., finally found time to break away from 1112 N. Broadway and call on the writer. Avery has had one of the busiest years of his life.

J. W. Skinner, after an absence of several years, showed up here last week. Idle at present.

Henry Reese is going to start on his street paving job in Quincy, Ill., as soon as the weather permits this spring.

W. A. Kettlewell, Iowa City, Ia., wants to rent a few team outfits by the day or month this spring.

Contracters when in want of work or labor for their outfits write Koenig Labor Agency, 612 Walnut street, St. Louis, Mo.; 503 Delaware street, Kansas City, Mo., or 509 S. 13th street, Omaha, Neb.

R. F. Haupt, assistant superintendent of Cameron, Joyce & Co., Keokuk, Ia., was here the other day looking for a team outfit to sublet 40,000 yards of state road work near Stubblefield, Ill. Haupt says this is a splendid piece of work and is offering attractive prices for it.

Z. C. Mitchell, superintendent of the L. J. Smith Construction Co., is sticking pretty close to their big steam shovel job on the White River branch of the Missouri Pacific R. R. in northwestern Arkansas. Mitchell is piling up some nice estimates on this job.

R. T. Ames, superintendent of A. L. Cook, is going to move a team outfit onto a small job of grading that he is doing for the M., K. & T. R. R. in North St. Louis.

Nick Marsch, of John Marsch, Inc., was here. Sublet some station work that they have north of East St. Louis to Columbus S. Jones, the boss station man.

Ralph Thomas, representing the C. R. Cummins Co., is around looking for new work. Thomas is making his headquarters at the Deming Hotel, Terre Haute, Ind.

A. B. KOENIG.

Personals

Judge B. M. Allen of Birmingham, Ala., has been elected president of the Bankhead National Highway Association.

C. L. Wood, for the past four years County Engineer of Lowndes County, Mississippi, has been reappointed at an increased salary.

W. Baker Hall, of Charleston, W. Va., has been appointed assistant engineer for the public service commission of West Virginia, succeeding William Q. Gallaher, promoted to the office of chief engineer.

Alexander W. Vars has resigned as town surveyor of Westfield, N. J., to accept the position of city engineer of Plainfield, N. J. C. W. Collins succeeds him as town surveyor

Roswell D. Trimble has resigned from Winston & Co., Richmond, Va., and New York, and has organized the firm of R. D. Trimble & Co., consulting and constructing engineers, with offices in the Allison Bldg., Richmond, Va.

W. R. Kelley, formerly associated with J. F. Everett under the firm name of Everett & Kelly, architects in the Boston Block, Seattle, Wash., has opened offices in the Gasco Bldg., Portland, Ore., to engage in railroad contracting.

E. H. Morris, for the past 3 years assistant engineer in charge of the department of railway work of the public service commission of Indiana, has been appointed chief engineer of the division of public utilities of North Dakota, with a salary of $4,000 a year.

John Cary Regan has been appointed Special Field Representative of the Chicago Chapter, American Association of Engineers. Mr. Regan has had a large and varied experience abroad, in matters directly bearing on engineering, construction, industrial and economic matters.

Ralph Budd, former chief engineer of the Spokane & Inland, Spokane, Portland & Seattle and Great Northern R. R., is to become the active head of the Great Northern R. R., succeeding Louis W. Hill, who will retire shortly after the railroads are returned to private ownership.

Colonel Gabriel R. Solomon, recently officer in charge of the engineering branch, construction division of the Army, and formerly of the Solomon-Norcross Co., consulting engineers, Atlanta, Ga., has been discharged from the Army, and has resumed his engineering practice as vice president of the Fuller Industrial Engineering Corporation, Fuller (Flatiron) Bldg., 949 Broadway, New York City.

Dorsey W. Hyde, Jr., has resigned as librarian of the New York Municipal Reference Library to accept a position as chief of the motor truck research bureau of the Packard Motor Car Co. of Detroit, Mich. The bureau will be a new development of the company's service, aiming at the collection and classification of all data pertaining to transportation problems and their solution. Mr. Hyde will be succeeded at the Municipal Reference Library by Miss Rebecca B. Rankin, who has served as assistant librarian during the past year.

Industrial Notes

J. E. Moody, chief engineer of the Massey Concrete Products Corporation, Chicago, will have charge of the concrete pipe division of the American Concrete Pipe Association at its convention at the Great Northern Hotel and the rooms of the Western Society of Engineers on Feb. 20 and 21.

The Duff Jack Sales Co., Ltd., located in the Oxford Circus House, 245 Oxford street, London, W. I., England, has been formed to represent the Duff Manufacturing Co. of Pittsburgh in the British Isles, and has been given the exclustive agency in that territory for Duff and Barrett jacks.

The Automatic Fuel Saving Co. of Philadelphia has purchased from the Vapor Vacuum Heating Co. and George C. G. Gray, the patent and good will of the Gray system of combustion control for power plants. The system has been known as the Gray system and the oilseal combustion control apparatus. The new company has adopted the name of Automatic Fuel Saver.

Freyn, Brassert & Co., Engineers, Peoples Gas Bldg., Chicago, have made arrangements with the Gellert Engineering Co. of Philadelphia for the mutual handling of Cottrell electrical blast furnace gas cleaners for the entire world. Freyn, Brassert & Co. will have exclusive charge of sales and will co-operate with the Gellert Engineering Co., who are the exclusive builders of the Cottrell cleaner in the United States, in the installation and practical adaptation of this apparatus to the particular requirements of blast furnace practice.

About 100 distributors of Rex mixers and pavers, representing practically all important cities in the United States and Canada, met in Milwaukee on Jan. 19, 20 and 21, for the annual convention of Chain Belt Co.'s mixer sales representatives. The program included meetings at the Milwaukee Athletic Club, visits to several prominent industrial plants, sales demonstrations, entertainments and demonstrations of improved Rex mixer and paver models at the company's new mixer plant at West Milwaukee. The sessions were presided over by C. F. Messinger of Chain Belt Co., and discussions were led by B. F. Devine, S. Shafer, Jr., J. W. Millspaugh and A. E. Miller of the company and K. B. Nohle and M. R. Hunter of the distributors. The annual banquet of Rex mixer representatives was held on Jan. 20 and attended by approximately 175 distributors, members of the Chain Belt Co. and guests. It was announced that the company's new building with an area of 47,000 sq. ft. for the exclusive manufacture of Rex concrete mixers and pavers would be ready for manufacturing operations about March 1st. This building is the first unit of an extensive building program which will eventually mean the removal of the entire Chain Belt plant to the 23 acre site in West Milwaukee.

Obituaries

A. C. Hansen, city engineer of Los Angeles, Cal., died Feb. 9.

Ellsworth S. Sweet, contractor and builder of the Fabyan House and other hotels in the White Mountains region, as well as on islands in Casco Bay, died Feb. 6, at Portland, Me., aged 83.

Edward E. Goff, for 5 years city engineer of Cranston, R. I., died Feb. 9. He had taken active part in the building of the Pawtuxet Valley branch and Oakland Beach branch of the New Haven railroad. He also took part in laying out plans for the state institutions.

Frederick Holbrook, head of the Holbrook, Cabot & Rollins Corp., Boston, Mass., died Feb. 6 in Paris, France. Holbrook became vice president of the American International Corporation in 1916, and assumed charge of the Russian affairs of the corporation. He remained in Russia for a year. In March, 1918, he became president of the American International Shipbuilding Corporation and was in charge of the work at Hog Island for the remainder of that year. Early in 1919 the Graeco-American International Corporation was formed to engage in business in Russia, and Mr. Holbrook became president. He sailed for Russia last December. Mr. Holbrook was born in Boston 58 years ago. Intending to become a lawyer, he prepared for Columbia University, but when his eyesight began to fail he went west and passed a few years on a ranch, where he studied engineering. Later he entered the service of the Union Pacific Railroad Co. as engineer. Subsequently as engineer on the N. Y., N. H. & H. R. R., he constructed a number of big bridges and at Brockton eliminated the grade crossings. In 1900 he formed his Boston construction firm which constructed the Charles River Basin and Esplanade, the West Boston Bridge, the Boston drydock and another in Brooklyn.

Building and Structural Monthly Issue

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Roads and Streets—1st Wednesday
- (a) Roads
- (b) Streets
- (c) Street Cleaning
- (d) Municipal Miscellanies
- (e) Management and Office System

Waterworks and Hydraulics—2nd Wednesday
- (a) Waterworks
- (b) Sewers and Sanitation
- (c) Irrigation and Drainage
- (d) Power and Pumping
- (e) Management and Office System

Railways and Excavation—3rd Wednesday
- (a) Excavation and Dredging
- (b) Rivers and Canals
- (c) Quarries and Pits
- (d) Railways, Steam and Electric
- (e) Management and Office System

Buildings and Structures—4th Wednesday
- (a) Buildings
- (b) Bridges
- (c) Harbor Structures
- (d) Miscellaneous Structures
- (e) Properties of Materials
- (f) Management and Office System

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Why the Railway Brotherhoods Have Become Socialistic

Now that the lower house of Congress has passed the compromise railway bill there is little doubt that the railways will be returned to their owners the first of March. The only strong opposition to the bill has come from the railway brotherhoods. Having committed themselves to government ownership, the railway unions not only have fought against the return of the railways to private management, but have declared their determination to continue their advocacy of government operation.

In their arguments against private ownership, the leaders of the railway brotherhoods have been neither logical nor fair. Their logic is at fault when they contend that government operation will result in lower transportation costs, for the government never has been known to operate anything with as great economy as under private operation. Their justice is lame, for they class the majority of railway investors with Wall Street speculators. They argue against guaranteeing to the railway companies a 5.5 to 6 per cent annual profit on the invested capital, and this argument is made on the ground that "Wall Street" should not be insured against loss.

To begin with "Wall Street" owns very little railway stock. Large individual investors disposed of most of their railway stock ten years ago, when public service commissions began to reduce railway rates. But the greatest unfairness on the part of the leaders of the railway unions is involved in their failure to mention the fact that since the public, through its rate regulating commissions, has chosen to hold railway rates down so as to yield a very small dividend, therefore the public should at least guarantee the continuity of those meager returns to the investors.

Certain radicals are at present in control of the railway unions. This is clear from their extremely intemperate utterances during their recent appeals to Congress. But it would be unwise to infer that this is a passing symptom of unrest among railway employes. In our opinion the cause of this unrest is to be found mainly in the persistence with which railway managers held the employes to low wages for years prior to the war. Prices had been rising steadily since 1896, and railway wage rates had barely kept pace with rising costs of living. This would probably have caused no great dissatisfaction had it not been evident that employes in many other industries had been able to secure a more rapid rate of increase in their income. When the war-begotten rise of prices began to irritate still more the already irritated railway workers, the railway operators held out no hope of a substantial increase in wages. At this juncture President Wilson stepped in and

28 Pages=40 pages

The 28 pages of articles in Engineering and Contracting contain as many words as 40 pages of the size and typography commonly used by other engineering periodicals. Ours is the same size of type and type-page as that of The Literary Digest—easily read, yet giving a large volume of reading matter per page. Our 28 pages of articles would fill 112 pages of the standard 6x9 in. text-book. It would take 10 such books of 580 pages each to hold all the articles printed each year in Engineering and Contracting, to say nothing of our weekly construction news.

forced upon the railways what was equivalent to a 25 per cent increase in wages for trainmen. Shortly afterward the government assumed the management of the rails, and other substantial increases in wages immediately followed. Small wonder that the railway unions began to look upon Uncle Sam as a fairy whose wand could always be counted upon to wave to them a higher income whenever they asked for it. Small wonder that they "fell for" the Plumb plan of railway nationalization. After a dozen years of rather "poor picking" in their struggle to get higher wages, the ease with which several big increases were secured from the government naturally made railway employes anxious to change employers.

Yet, if those same railway unionists will but survey the wage field a bit more carefully, they will see that their Uncle Sam is a very stingy employer. They need look no farther than the Post Office, for example. But if they want "the limit," let them look at the Army and Navy, where the enlisted men are housed, clothed and fed, but barely more.

If the railway brotherhoods imagine that they can beat Uncle Sam at his old game of paying low wages, because they are unionized, whereas Uncle Sam's other employes are not, let them consider how long it would be before the government would render their unionization ineffective by passing anti-strike laws.

The U. S. Steel Corporation has voluntarily doubled wage rates in five years, whereas Uncle Sam has increased the wages of railway employes only 43 per cent. Does this look like corporation niggardliness and government generosity? The fact is that almost every corporation that is operating profitably is liberal with its employes. Indeed we do not know of an exception to this rule. But for 15 years the railways have been steadily growing less and less profitable, squeezed as they were between rising prices and fixed or lowering rates. Through no fault of their own, railway operators have been compelled to hold wages down in order that some money for dividends should be available. Had the labor unions been wise in their day, they would have exerted their political influence to secure fair freight and passenger rates, out of which both fair wages and fair dividends could have been paid. Instead, the unions stood stupidly by, watching the railways slowly strangled to death by the Interstate Commerce Commission and the various state railway commissions. And now, even more stupidly the same unions bite the hands that have fed them and spit in the mouths of those that have spoken in their behalf at every rate hearing during these past 15 years.

An Engineer's Address That the Daily Papers Quoted

Herbert Hoover's inaugural address appears in this issue. It has been published in full in nearly all the metropolitan daily papers. We do not not recall a previous instance of wide quotation of an address of an engineer upon his election to the presidency of an engineering society. Mr. Hoover, it is true, is a national character, and is generally believed to be a possible candidate for the presidency of the United States. But this alone would not have led so many editors to run his entire inaugural address. The reason is that the address is not only non-technical but discusses matters of nation-wide importance in a statesmanlike manner.

This address is one of many recent signs that engineers are no longer confining their thoughts to technical economics but are beginning to encroach upon the pastures of the professors of political economy.

In discussing the recent coal strike, which was so far reaching in its effect as to become a political matter, Mr. Hoover characterizes the coal industry as "the worst functioning industry in the whole world." He points out that it lies within the province of the American Institute of Mining and Metallurgical Engineers to express an unbiased opinion as to how coal mining can be conducted so as to give more continuous employment to the miners.

Several weeks ago we expressed the same opinion as to coal mining, and for years we have held it to be one of the functions of engineering societies to solve certain political and industrial problems. But we have not stopped there in our suggestions, for we believe that engineering societies should do more than solve such economic problems. They should also lead the public to apply their solutions. Advice is good, but it is usually futile unless accompanied by an effort to secure its acceptance.

Engineering societies have at last reached the advisory stage of their political development, and some of them have begun to enter the propaganda stage. If engineering societies will spend a moderate amount of money and energy to persuade the public to follow their advice, it will not be many years before the wide publication of an engineer's address in daily papers will cease to be surprising. Moreover, engineers will be in great demand as public executives, and the era of science in political management will have arrived.

More Evidence That Many Engineers Are "Too Busy to Read"

The Engineering Societies Library contains more than 200,000 books. During the first half of last year the number of visitors to the library averaged only 78 per day. This pitifully small average indicates the relatively slight amount of research made by members of the four founder societies residing in and near New York City.

During the first five months of 1919 the Service Bureau of the library received 1,329 inquiries for photostat copies and abstracts of articles, bibliographies, translations, and the like, or about 10 per day. The average charge of these 1,329 orders was $6. In view of the fact that the library, in cooperation with the founder societies, publishes an index of current technical literature, it is astonishing that it receives only 10 inquiries daily for data mentioned in those indexes and elsewhere. More than 30,000 engineers are members of the founder societies, yet not 3,000 inquiries for information come annually from them to the Service Bureau of the library. If each one of these inquiries came from a different engineer, it would follow that only one engineer in ten inquires for information only once a year! As a matter of fact the record must be even worse than that, for some engineers inquire for information several times annually. Yet engineers pride themselves on being a studious and inquiring class of men. If they are studious and inquiring, as a class, they must confine their studies almost entirely to their local sources of information. But it is noteworthy that the libraries of local engineering societies are rarely well attended.

The inference is inescapable that practicing engineers, as a class, are not very studious. Are they "too busy to read"? If so, perhaps, that accounts in part for the failure of so many of them to succeed.

Tests of Old Storage Cement.—During the progress of the war large stocks of cement were often shipped to various jobs at the beginning of the work and stored until needed. In some cases this storage period amounted to more than a year, and several such samples were submitted for test. The results of tests made by the U. S. Bureau of Standards indicated reduction in strength for the storage cement, but this change was not marked for material which had been stored on the job for less than one year. One lot which had been in storage over two years gave the same strength in compression for 1:1½:3 concrete as was obtained for a 1:2:4 concrete made with the same brand of new cement. The old cement when gauged with a 5 per cent calcium-chloride solution showed an increase of about 30 per cent at seven days over the same cement gauged with ordinary mixing water.

Long Pre-Mixing of Cement and Water Does Not Add to Strength of Concrete. To determine the benefit to strength due to mixing of cement and water for a long period (15 to 30 minutes), and then adding aggregate to produce a concrete instead of the ordinary method of mixing cement, aggregate, and water together for one to two minutes, comparative tests of concrete by the two methods were made last year by the U. S. Bureau of Standards. Exactly the same materials and amount of water were used, using exactly the same materials and amount of water. The compressive strengths obtained were about the same, indicating that there is no advantage in long premixing of cement and water from the standpoint of strength.

Book Reviews

Useful Data on Reinforced Concrete Buildings for the Designer and Estimator.—By the Engineering Staff of the Corrugated Bar Company, Inc., Buffalo, N. Y. Leather; 5x8 in.; pp. 216; illustrated; $2.50.

Reviewed by JOHN C. PENN,

Associate Professor of Hydraulic Engineering, Armour Institute of Technology, Chicago, Ill.

With so many variables in the subject of the design of reinforced concrete structures, it would seem almost hopeless to make up a "handbook" on the subject. However, this handbook, just published by the Corrugated Bar Co., of Buffalo, seems to answer all that might be desired in such a book. In fact, it is a parallel, in size, shape, and contents, to our familiar Carnegie, or Cambria of the steel companies. A "Useful Data on Reinforced Concrete Buildings," a Carnegie "Pocket Companion," and a "Structural Timber Handbook" (by the West Coast Lumbermen's Association), form a trio that are time savers and invaluable to the engineer who understands and appreciates the fundamentals of good designing. All handbooks are dangerous in the hands of the inexperienced.

"Useful Data" is in no sense an advertisement; in fact, deformed bars are not particularly mentioned. True enough, under the head of "Flat Slab Tables," the "Corr Plate Floors" have their place but so do the Flat Slab Floors, according to the Chicago Rulings and Joint Committee Recommendations.

A few pages are given over to a restatement of the ordinary reinforced concrete theory. Curves for the values of k, j, K, and p, for the usual values of n and f_s and f_c for various kinds of beams follow. Continuous beams are very well presented. Tables on slabs, clay tile slabs, ribbed slabs, rectangular beams, tee beams, occupy some 40 pages. Columns are given according to the New York City Building Code, Chicago Building Code, and the Joint Committee Recommendations. Square, round, tied, and spiral columns of all sizes are given. Footings, piles and retaining walls are well illustrated and detailed. Quantities for estimating purposes are included; straight steel, spirals, column and beam areas and weight and moments of inertias, column capitals, etc., are included under this. Pages of ordinary useful data are followed by specifications of various kinds, and the final report (July 1, 1916) of the Joint Committee is given in full. A good subject index completes the books.

Truly, according to the preface, text books deal with method and theory of design; this book gives quantitative results. The book is offered, according to the statement of the publishers, at a "nominal price, merely covering the actual mechanical cost of printing and binding."

Housing Shortages and Fire Proofing Measures.—The Ohio Builders Supply Association at its convention last month at Columbus, O., adopted the following resolution:

> Whereas, The housing shortage in the United States creates a serious situation; and
>
> Whereas; The fire losses reported in 1917 to the National Board of Fire Underwriters amounted to $66,166,420, in 232,021 residences; and,
>
> Whereas, The cost of material and labor is constantly mounting so that individual losses are likely to be greater year by year, putting down our national resources to a tremendous extent, and aggravating the housing situation to an unnecessary degree. Be it therefore
>
> Resolved, That this association go on record as to the necessity of giving more adequate fire protection to the combustible members of residences. Be it further
>
> Resolved, That each member of this association be requested to advise prospective owners of the situation and furnish full information as to the best available methods of protecting such structures

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Salaries of Baltimore City Engineers Increased.—The City Council of Baltimore, Md., has granted an increase in salary amounting to from 20 to 25 per cent. to all professional engineers employed by the city. Several months ago the Baltimore Chapter of the American Association of Engineers presented to the city a compensation report which contained a compilation of the various grades of engineer employes and the salaries which should obtain for each grade. The decision to grant the increase came after the diligent efforts of the chapter to convince the board of aldermen of the justness of its claims for greater compensation. The city engineer and the President of the Board of Public Works have issued a statement to the effect that the results were due entirely to the efforts of the chapter.

What Shall an Engineer Read in General Literature?

To the Editor: A friend recently sent me an article published under the above caption in "Engineering and Contracting" of May 28, 1919; the author was Mr. R. Fleming, of the American Bridge Co. Mr. Fleming says frankly that the books he mentions are those which he personally has found interesting, and that the best books for anyone to read are those that he likes best, regardless of the lists recommended by some one else. Yet it is interesting to know what books others like, and to criticize their choice.

In reading Mr. Fleming's list, I questioned his statement that "human thought reaches its highest level in two books of the Hebrew Scripture—Job and Isaiah." Why should Hebrew folklore and moralizing, expressed in antiquated and unnatural style, be accorded such superlative praise?

Again, Mr. Fleming overpraises the stories of Frank Stockton, it seems to me. Such stories are fairly interesting, but they are by no means the most wonderful stories in the world. Then, what dry and rather puritanical books Mr. Fleming selected among recent novels, "Angela's Business," for instance, impresses me as a book for a Sunday school teacher rather than for an engineer. And what a choice is "Pilgrim's Progress" as the greatest example of English prose! As well recommend an engineer to read childrens' books written by "pious humbugs," as Rebecca West calls them. Why not, rather, select Thomas Hardy, Anatole France, or Mark Twain?

However, I agree with Mr. Fleming in his advocacy of philosophy as good mental food for engineers. To learn to understand the teachings of Plato, Democritus and Kant, or to learn to enjoy the writings of men who were informal philosophers, like Carlyle, Emerson, and Darwin, is to discover a new world. I like, also, Mr. Fleming's remarks about poetry. No other writing is so condensed and so restful as poetry—nor so beautiful.

New York University. P. B. McDONALD.

A Plan to Effect Profitable Cooperation Between American Industry and the Technical Schools

Realizing that technical schools are not serving to a maximum degree the industrial market, the Technology Clubs Associated, through their president, Dr. Hollis Godfrey, have called a meeting at Drexel Institute, in Philadelphia, on March 25, 26 and 27. Dr. Godfrey, as chairman of the Engineering-Education Section of the Council of National Defense, during the period of the war, foresaw the alarming shortage of trained men. He saw that there was much waste in present technical education and that to eliminate this waste, industry must be called upon to specify exactly what they require of the graduating engineer. The following plan was, therefore, formulated. Since that time every detail of the plan has been worked out and will be presented at the coming meeting in Philadelphia.

A number of industries who saw the need for betterment each contributed $2,500 to carry on the study, and besides gave much of the time of their executives. Educators who were also engineers were sent out into the industry. They made a study of manufacturing process to determine what knowledge was essential, if men were to be successful in the various fields. They called conferences of executives and obtained facts regarding training from them. They sat in foremen shop meetings, and talked with the operators at their machines. They made every effort possible to determine industrial demand upon the educational institution. Their findings, together with the suggestion of the representative plant visited, were submitted to a board of educational experts who outlined courses and formulated plans to meet the industrial demand with the possible educational supply. At the meeting of the Technology Clubs Associated there will be gathered representatives of educational institutions and of industry. At that time a composite plan for future education will be worked out. The results of preliminary studies and of the meeting will be put into a permanent record, in book form and in terms common to all concerned.

Inaugural Address of President Herbert C. Hoover Delivered Feb. 17 Before American Institute of Mining Engineers

I have been greatly honored as your unanimous choice for president of this institute, with which I have been associated during my entire professional life. It is customary for your new president, on these occasions, to make some observation on matters of general interest from the engineer's standpoint

The profession of engineering in the United States comprises not alone scientific advisers on industry, but is in great majority comprised of the men in administrative positions. In such positions they stand midway between capital and labor. The character of your training and experience leads you to exact and quantitative thought. This basis of training in a great group of Americans furnished a wonderful recruiting ground for service in these last years of tribulation. Many thousands of engineers were called into the army, the navy and civilian service for the government. Thousands of high offices were discharged by them with credit to the profession and the nation.

We have in this country probably 100,000 professional engineers. The events of the last few years have greatly stirred their interest in national problems. This has taken practical form in the maintenance of joint committees for discussion of these problems and support to a free advisory bureau in Washington. The engineers want nothing for themselves from Congress. They want efficiency in government, and you contribute to the maintenance of this bureau out of sheer idealism. This organization for consideration of national problems has had many subjects before it, and I propose to touch on some of them this evening.

Post-War Problems.—Even more than ever before is there necessity for your continued interest in this vast complex of problems that must be met by our Government. We are faced with a new orientation of our country to world problems. We face a Europe still at war; still amid social revolutions; some of its peoples still slacking on production; millions starving, and therefore, the safety of its civilization is still hanging by a slender thread. Every wind that blows carries to our shores an infection of social disease from this great ferment; every convulsion there has an economic reaction upon our own people. If we needed further proof of the interdependence of the world, we have it today in the practical blockade of our export market. The world is asking for us to ratify long delayed peace in the hope that such confidence will be restored as will enable her to reconstruct her economic life. We are today contemplating maintenance of an enlarged army and navy in preparedness for further upheavals in the world and failing to even provide some insurance against war by a league to promote peace.

Out of the strain of war, weaknesses have become even more evident in our administrative organization, in our legislative machinery. Our federal government is still overcentralized, for we have upon the hands of our government enormous industrial activities which have yet to be demobilized. We are swamped with debt and burdened with taxation. Credit is woefully inflated; speculation and waste are rampant. Our own productivity is decreasing. Our industrial population is crying for remedies to the increasing cost of living and aspiring to better conditions of life and labor. But, beyond all this, great hopes and aspirations are abroad; great moral and social forces have been stimulated by the war and will not be quieted by the ratification of peace. These are but some part of the problems with which we must deal. I have no fear that our people shall not find solutions; but progress is sometimes like the old-fashioned rail fence—some rails are perhaps misshapen and all look to point the wrong way, but in the end, the fence progresses.

Your committees jointly with those of other engineering societies have had before them and expressed their views in many matters concerning the handling of the railways, shipping, the reorganization of the government engineering work, the national budget, and other practical items.

Experiments in Socialism.—The war nationalization of railways and shipping are our two greatest problems in government control awaiting demobilization. There are many fundamental objections to continuation of these experiments in socialism necessitated by the war. They lie chiefly in their destruction of initiative in our people and the dangers of political domination that can grow from governmental operation. Beyond this, the engineers will hold that the successful conduct of great industries is to a transcendant degree dependent upon the personal abilities and character of their employes and staff. No scheme of political appointment has ever yet been devised that will replace competition in its selection of ability and character. Both shipping and railways have today the advantage of many skilled personnel, sifted out in the hard school of competition, and even then the government operation of these enterprises is not proving satisfactory. Therefore, the ultimate inefficiency that would arise from the deadening paralysis of bureaucracy has not yet had full opportunity for development. Already we can show that no government under pressure of ever-present political or sectional interests can properly conduct the risks of extension and improvement, or can be free from local pressure to conduct unwarranted service in industrial enterprise. On the other hand, our people have long since recognized that we cannot turn monopoly over to unrestrained operation for profit nor that the human rights of employes can ever be dominated by dividends.

Our business is handicapped on every side by the failure of our transportation facilities to grow with the country. It is useless to talk about increased production to meet an increased standard of living in an increasing population without a greatly increased transport equipment. Moreover, there are very great social problems underlying our transport system; today their contraction is forcing a congestion of our population round the great cities with all that these overswollen settlements import. Even such great disturbances as the coal strike have a minor root in our inadequate transportation facilities and their responsibility for intermittent operation of the mines.

Railway and Shipping Problems.—We are all hoping that Congress will find a solution to this problem that will be an advanced step toward the combined stimulation of the initiative of the owners, the efficiency of operation, the enlistment of the good will of the employes, and the protection of the public. The problem is easy to state. Its solution is almost overwhelming in complexity. It must develop with experience, step by step toward a real working partnership of its three elements.

The return of the railways to the owners places predominant private operation upon its final trial. If instant energy, courage and large vision in the owners should prove lacking in meeting the immediate situation we will be faced with a reaction that will drive the country to some other form of control. Energetic enlargement of equipment, better service, co-operation with employes, and the least possible advance in rates together with freedom from political interest will be the scales upon which the public will weigh these results.

Important phases of our shipping problem that have come before you should receive wider discussion by the country. As the result of war pressure, we will spend over $2,800,000,000 in the completion of a fleet of 1,900 ships of a total of 11,000,000 tons—nearly one-quarter of the world's cargo shipping. We are proud of this great expansion of our marine, and we wish to retain it under the American flag. Our shipping problem has one large point of departure from the railway problem, for there is no element of natural monopoly. Anyone with a water-tight vehicle can enter upon the seas today, and our government is now engaged upon the conduct of a nationalized industry in competition with our own people and all the world besides. While in the railways government inefficiency could be passed on to the consumer, on the seas we will sooner or later find it translated to the national treasury.

Government Operation of Ships.—Until the present time there has been a shortage in the world's shipping, but this is being rapidly overtaken, and we shall soon be met with fierce competition of private industry. If the government continues in the shipping business, we shall be disappointed from the point of view of profits. For we shall be faced with the cargo for all legs of a voyage, and these arrangements of co-operation cannot be created by government employes without charge or danger of favoritism. Lest fault be found, our government officials are unable to enter upon the detailed higgling in fixing rates required by every cargo and charter. Therefore, they must take refuge in rigid regulations and in fixed ability of private enterprise to make profits from the margins of higher cost of government operation alone. Aside from those losses inherent in bureaucracy and political pressure, there are others special to this case. The largest successfully managed cargo fleet in the world comprises about 120 ships, and yet we are attempting to manage 1,900 ships at the hands of a government bureau. In normal times the question of profit or loss in a ship is measured by a few hundred tons of coal wasted, but a little extravagance in repairs, or by the four or five days on a round trip. Beyond this, private shipping has a free hand to set up such give-and-take relationships with merchants all over the world as will provide sufficient rates. In result, their competitors underbid by the smallest margins necessary to get the cargoes. The effect of our large fleet in the world's markets is thus to hold up rates, for so long as this great fleet in one hand holds a fixed rate others will only barely underbid. If we hold up rates an increasing number of our ships will be idle as the private fleet grows. On the other hand, if we reduce rates we shall be underbid until the government margin of larger operation cost causes us to lose money.

American Yards Can Compete with Any Foreign Ship Builder.—We shall yet be faced with the question of demobilizing a considerable part of this fleet into private hands, or frankly acknowledge that we operate it for other reasons than interest on our investment. In this whole problem there are the most difficult considerations requiring the best business thought in the country. In the first instance, our national progress requires that we retain a large fleet under our flag to protect our national commercial expansion overseas. Secondly we may find it desirable to hold a considerable government fleet to build up trade routes in expansion of our trade, even at some loss in operation. Thirdly, in order to create this fleet, we have built up an enormous shipbuilding industry. Fifty per cent of the capacity of our shipyards will more than provide any necessary construction for American account. Therefore there is a need of obtaining foreign orders, or the reduction of capacity, or both. I believe, with most engineers, that, with our skill in repetition manufacture, we can compete with any shipbuilders in the world and maintain our American wage standards; but this repetition manufacture implies a constant flow of orders. It would seem highly desirable, in order to maintain the most efficient yards until they can establish themselves firmly in the world's industrial fabric, that the government should continue to let some ship construction contracts to the lowest bidders, these contracts to supplement private building in such a way as to maintain the continuous operation of the most economical yards and the steady employment of our large number of skilled workers engaged therein.

When we consider giving orders for new ships we must at the same time consider the sale of ships, as we cannot go on increasing this fleet. When we consider sale we are confronted with the fact that our present ships were built under expensive conditions of war, costing from three to four times per ton the pre-war amount, and that already any merchant, subject to the long time of delivery, can build a ship for 75 per cent of their cost. It would at least seem good national policy to sell ships today for the price we can contract for delivery a year or two hence, thus making the government a reservoir for continuous construction.

We could thus stabilize building industry to some degree and also bring the American-owned fleet into better balance, if, as the government sold three or four emergency constructed cargo vessels it gave an order for one ship of a better and faster type. This would make reduction in our shipbuilding steadier and would give the country the type of ships we need.

Public Works and Technical Services.—Our joint engineering committees have examined with a great deal of care into organization of and our expenditure on public works and technical services. These committees have consistently and strongly urged the appalling inefficiency in the government organization of these matters. They report to you that the annual expenditure on such works and services now amounts to over $250,000,000, and that they are carried out today in nine different governmental departments. The report that there is a great waste by lack of national policy of co-ordination, in overlapping with different departments, in competition with each other in the purchase of supplies and materials and the support of many engineering staffs.

They recommend the solution that almost every other civilized government has long since adopted, that is, the co-ordination of these measures into one department under which all such undertakings should be conducted and controlled. As a measure practical to our government, they have advocated that all such bureaus should be transferred to the Interior Department, and all the bureaus not relating to these matters should be transferred from the Interior to other departments. The committee concludes that no properly organized and directed saving in public works can be made until such a regrouping and consolidation is carried out, and that all of the cheese-paring that normally goes on in the honest effort of congressional committees to control departmental expenditure is but a tithe of that which could be effected if there were some concentration of administration along the lines long since demonstrated as necessary to the success of private business.

National Budget.—Another matter of government organization to which our engineers have given adhesion is in the matter of the national budget. To minds charged with the primary necessity of advance planning, co-ordination, provision of synchronizing parts in organization, the whole notion of our hit-or-miss system is repugnant. A budget system is not the remedy for all administrative ills; it provides a basis of organization that at least does not paralyze administrative efficiency as our system does today. Through it, the coordination of expenditure in government departments, the prevention of waste and overlapping in government bureaus, the exposure of the pork barrel, and the balancing of the relative importance of different national activities in the allocation of our national income can all be greatly promoted. Legislation would also be expedited. No budget that does not cover all government expenditure is worth enactment. Furthermore, without such re-organization as the grouping of construction departments, the proper formulation of a budget would be hopeless. The budget system in some form is so universal in civilized governments and in competently conducted business enterprise, and has been adopted in thirty of our states, that its absence in our federal government is most extraordinary. It is, however, but a further testimony that it is always a far cry of our citizens from the efficiency in their business to interest in the efficiency of their government.

Relationship of Employer and Employe in Industry. Another great national problem to which every engineer in the United States is giving earnest thought, and with which he comes in daily contact, is that of the relationship of employer and employe in industry. In this, as in many other national problems today, we are faced with a realization that the science of economics has altered from a science of wealth to a science of human relationships to wealth. We have gone on for many years throwing the greatest of our ingenuity and ability into the improvement of processes and tools of production. We have until recently greatly neglected the human factor that is so large an element in our very productivity. The development of vast repetition in the process of industry has deadened the sense of craftsmanship and the great extension of industry has divorced the employer and his employe from that contact that carried responsibility for the human problem. This neglect of the human factor has accumulated much of the discontent and unrest throughout our great industrial population and has reacted in a decrease of production. Yet our very standards of living are dependent on a maximum productivity up to the total necessities of our population.

"Another economic result is, or will be yet, a repercussion upon the fundamental industry of the United States, that is, agriculture. For the farmer will be unable to maintain his production in the face of a constant increase in the cost of his supplies and labor through shrinkage in productivity in other industries. The penalty of this disparity of effort comes mainly out of the farmer's own earnings.

I am daily impressed with the fact that there is but one way out, and that is to again re-establish through organized representation that personal co-operation between employer and employe in production that was a binding force when our industries were smaller of unit and of less specialization. Through this, the sense of craftsmanship and the interest in production can be recreated and the proper establishment of conditions of labor and its participation in a more skilled administration can be worked out. The attitude of refusal to participate in collective bargaining with representatives of the employes' own choosing is the negation of this bridge to better relationship. On the other hand, a complete sense of obligation to bargains entered upon is fundamental to the process itself. The interests of employe and employer are not necessarily antagonistic; they have a great common ground of mutuality and if we could secure emphasis upon these common interests, we would greatly mitigate conflict. Our government can stimulate these forces, but the new relationship of employer and employe must be a matter of deliberate organization within industry itself. I am convinced that the vast majority of American labor fundamentally wishes to co-operate in production and that this basis of good will can be organized and the vitality of production re-created.

Many of the questions of this industrial relationship involve large engineering problems, as an instance of which I know of no better example than the issue you plan for discussion in connection with the soft coal industry. Broadly, here is an industry functioning badly from an engineering and consequently from an economic and human standpoint. Owing to the intermittency of production, seasoned and local, this industry has been equipped to a peak load of 25 or 30 per cent over the average load. It has been provided with a 25 or 30 per cent larger labor complement than it would require if continuous operation could be brought about. I hope your discussion will throw some light on the possibilities of remedy. There lies in this intermittency not only a long train of human misery through intermittent employment, but the economic loss to the community of over 100,000 workers who could be applied to other production, and the cost of coal could be decreased to the consumer. This intermittency lies at the root of the last strike in the attempt of the employes to secure an equal division among themselves of this partial employment at a wage that could meet their view of a living return on full employment.

Radicalism and Reaction.—These are but few of the problems that confront us. But in the formulating of measures of solution, we need a constant adherence to national ideal and our own social philosophy.

In the discussion of these ideals and this social philosophy, we hear much of radicalism and of reaction. They are, in fact, not an academic state of mind, but realize into real groups and real forces, influencing the solution of economic problems in this community. In their present day practical aspects, they represent on one hand roughly various degrees of exponents of socialism, who would directly or indirectly undermine the principle of private property and personal initiative, and, on the other hand, those exponents who in various degrees desire to dominate the community for profit and privilege. They both represent attempts to introduce or preserve class privilege, either a moneyed or a bureaucratic aristocracy. We have, however, in American democracy an ideal and a social philosophy that sympathizes neither with radicalism nor reaction as they are manifested today.

For generations the American people have been steadily developing a social philosophy as part of their own democracy, and in these ideals, it differs from all other democracies. This philosophy has stood this period of test in the fire of common sense; it is, in substance, that there should be an equality of opportunity—an equal chance—to every citizen. This view that every individual should, within his lifetime, not be handicapped in securing that particular niche in the community to which his abilities and character entitle him, is itself the negation of class. Human beings are not equal in these qualities. But a society that is based upon a constant flux of individuals in the community, upon the basis of ability and character, is a moving, virile mass; it is not a stratification of classes. Its inspiration is individual intiative. Its stimulus is competition. Its safeguard is education. Its greatest mentor is free speech and voluntary organization for public good. Its expression in legislation is the common sense and common will of the majority. It is the essence of this democracy that progress of the mass must arise from progress of the individual. It does not permit the presence in the community of those who would not give full meed of service.

Its conception of the State is one that, representatives of all the citizens will, in the region of economic activities, apply itself mainly to the stimulation of knowledge, the undertaking only of works beyond the initiative of the individual or group, the prevention of economic domination of the few over the many, and the least entrance into commerce that government functions necessitate.

The method and measures by which we solve this accumulation of great problems will depend upon which of these three conceptions will reach the ascendancy amongst our people.

If we cling to our national ideals it will mean the final isolation and the political abandonment of the minor groups who hope for domination of the Government, either by 'interests' or by radical social theories through the control of our political machinery. I sometimes feel that lawful radicalism in politics is less dangerous than reaction, for radicalism is blatant and displays itself in the open. Unlawful radicalism can be handled by the police. Reaction too often fools the people through subtle channels of obstruction and progressive platitudes. There is little danger of radicalism ever controlling a country with so large a farmer population, except in one contingency. This contingency is from a reflex of continued attempt to control this country by the 'interests' and other forms of our domestic reactionaries.

The mighty upheaval following the world war has created turmoil and confusion in our own country no less than in all other lands. If America is to contribute to the advance of civilization it must first solve its own problems; must first secure and maintain its own strength. The kind of problems that present themselves are more predominently economic—national as well as international—than at any period in our history. They require quantitative and prospective thinking and a sense of organization. These are the sort of problems that your profession deals with as its daily toil. You have an obligation to continue the fine service you have initiated and to give it your united skill.

Salvaging Old Reinforcing Steel

During the great flood of July, 1916, the reinforced concrete bridge over the Catawba River near Belmont, N. C., was destroyed. In replacing this bridge with a series of reinforced concrete arches and girder spans a considerable saving of money was made by utilizing the steel imbedded in the original wrecked structure. Regarding this the State Highway Engineer for North Carolina, Mr. W. S. Fallis, in his report for 1917-1918, gives the following:

On account of the greatly increased cost of reinforcing steel, as well as its scarcity, and the congested shipping facilities due to war conditions, it was decided to attempt to break up the old wrecked concrete and to salvage therefrom the old reinforcing steel. Very gratifying and interesting results were obtained. It was impossible to let this salvage work to contract, so the counties agreed to furnish the necessary labor and tools, and the work of salvage was carried out under the personal direction and supervision of the Highway Commission's engineer. Over 100,000 lb. of steel was secured in this way. The concrete was broken with sledge hammers and dynamite; and, strange to say, generally the hammers were more effective than the dynamite. The steel was bent into every conceivable shape, and had, of course, to be straightened out and sorted. It was not found to be damaged in the least. The total cost of salvaging this steel, including the engineer's salary, was only $1\frac{1}{4}$ ct. per pound, and is considered a remarkable showing. In this way alone, through the assistance of the State Highway Commission, the counties cleared between $3,000 and $4,000 on steel, which they had not anticipated.

Increased Salaries Recommended for Municipal Engineers.—The Twin City Chapter of the American Association of Engineers has submitted a compensation report to the city of Minneapolis which contains recommended salaries for all grades of engineers employed by the city. The recommended salary for the city engineer varies from $7,500 to $15,000 per annum; that of the assistant city engineer from $5,000 to $7,500. Sewer engineer, bridge engineer and engineers of construction, streets, etc., are recommended for salaries ranging from $3,000 to $5,000 per annum. The range for assistant is from $2,400 to $3,600.

Moments in External Columns of a Building

By W. M. WILSON and F. E. RICHART.

The external columns of a building are subjected to bending moments from two sources, the unbalanced loads from the floors on the inside of the columns and eccentric loads due to curtain walls, cornices, parapets, etc., on the outside of the columns.

Within the last few years considerable attention has been paid to these moments. This is apparent from the fact that various building codes specify the moments for which exterior columns are to be designed. For example, the final report of the Joint Committee on Concrete and Reinforced Concrete says, with reference to flat slab construction

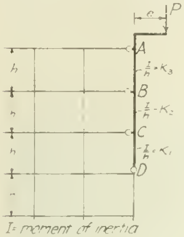


Fig. 1.

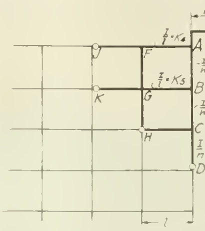


Fig. 3.

> Provision should be made in both wall columns and interior columns for the bending moment which will be developed by unequally loaded panels, eccentric loading, or uneven spacing of columns. The amount of moment to be taken by a column will depend upon the relative stiffness of columns and slabs and computations may be made by rational methods, such as the principle of least work, or of slope and deflection. Generally the larger part of the unequalized negative moment will be transmitted to the columns and the columns shall be designed to resist this bending moment. Especial attention should be given to wall columns and corner columns.

The Chicago building regulations require exterior columns supporting flat slab floors to be designed for .4 of the full negative moment in the slab at interior columns. For columns at the roof level this moment is doubled. The standard building regulations for the use of reinforced concrete proposed by the American Concrete Institute require a minimum exterior column moment of about .5 of the full negative moment in the slab at interior columns, when no dropped panel is used. In all cases the moment of both live and dead loads is considered. Philadelphia and Cincinnati have adopted similar rulings.

The moment produced by an eccentric load is the product of the load and the eccentricity, and can be computed if the load and the eccentricity are known. That is, the moment to be resisted is independent of the relative stiffness of the columns and girders. In the case of a frame for which the connections of the girders to the columns are hinged the moment in the columns due to the eccentrically connected girders is produced in the same way as the moment due to a curtain wall. That is, the moment to be resisted is due to a known load with a known eccentricity and its magnitude is independent of the relative stiffness of the different members.

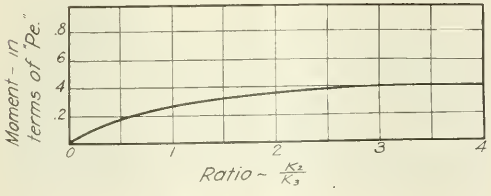


Fig. 2—Values of Moment Mba in Fig. 1.

In the case, however, of a building frame having rigid joints connecting the girders to the columns, the moment to be resisted as well as the distribution of the resisting moment is dependent upon the relative stiffness of the members. The problem of moments in external columns will, therefore, be divided into two parts, as follows:

1. Moments in columns due to eccentric loads.
2. Moments in columns due to loads on rigidly connected girders.

These two cases will be treated separately.

Moment Due to Eccentric Loads.

Eccentric Load at Top of Column; Girder Connections Hinged. Figure 1 represents the frame of a building for which the joints connecting the girders to the external column are hinged. By inspection the load P produces a moment Pe at the point A. The moments at the points B and C depend upon the relative stiffness of the different stories of the column. Fig. 2 shows the moment at point B for different relations between the column stiffness above and below point B. The ratio of K_2 to K_3 usually is not less than one nor more than two so that the moment at the point B usually varies between .27 Pe and .35 Pe. The necessity of considering this moment depends upon the value of Pe. The moment at point C due to P is very small, being only .07 Pe when the K's for all column stories are equal.

The girder load at A produces a counteracting moment. The moment Pe used in connection with Fig. 2 may be the resultant of the moments due to the overhanging load and the moment due to the floor at A. The moment at point B due to the eccentric floor load at B acts with the moment at B due to P and against the moment at B due to the floor load at A.

Eccentric Load at Top of Column; Girder Connections Rigid.—Figure 3 represents the top stories of a building frame for which the connections of the girders to the external column are rigid. By inspection the moment in the external column just above A is Pe. This moment tends to rotate the point A in a clockwise direction. Rotation of point A is prevented by the moment at A in the members AF and AB. Representing the moment at A in the member AF by M_{AF} and the moment at A in member AB by M_{AB}, $M_{AB} = Pe \dfrac{K_1}{K_1 + K_4}$ and $M_{AF} = Pe \dfrac{K_4}{K_1 + K_4}$. These equations are true if the degrees of restraint at B and F are equal. They are near enough true for purposes of design even though the degrees of restraint at B and F are not equal.

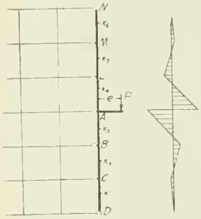


Fig. 4.

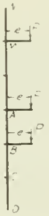


Fig. 5.

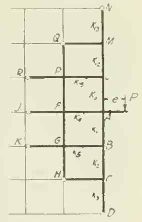


Fig. 6.

The moment in the column AB just above B, represented by M_{BA}, depends upon the relative stiffness of the columns and girders intersecting at A and B. If the K's of all members are equal $M_{BA} = .17$ Pe. The magnitude of M_{BA} increases as the ratio of K for columns to K for girders increases. If the K's of all members are not equal the moments M_{BA}, M_{BG}, and M_{BC} can be determined approximately as follows: Determine M_{AB} and M_{AF} as outlined above. M_{BA} is approximately ⅓ M_{AB}. $M_{BG} = M_{BA} \dfrac{K_5}{K_5 + K_2}$ and $M_{BC} = M_{BA} \dfrac{K_2}{K_5 + K_2}$.

If all K's are equal $M_{BG} = M_{BC} = 1/12$ Pe.

Eccentric Loads on External Column at Intermediate Floors; Connections of Girders to Column Hinged.—Figure 4 represents a frame of a building carrying an eccentric load at an intermediate floor of an external column. The connections of the girders to the column are hinged. The force P produces a moment Pe which tends to rotate the point A. This rotation is prevented by the resisting moment in the columns AL and AB. The force P also produces a moment over the entire length of the column but the magnitude of this moment varies with the distance from P. The moment in the column is represented graphically by the moment diagram to the right of Figure 4. The moment M_{AL} due to P is given by the equation $M_{AL} = Pe \frac{K_4}{K + K_4}$ and $M_{AB} = Pe \frac{K}{K + K_4}$. If $K = K_4$, $M_{AL} = M_{AB} = \frac{1}{2} Pe$. Te moments at point L and point B depend upon the relative values of the K's for the different stories of the column. If the K's for all column stories are equal $M_{LA} = M_{BA} = .133$ Pe. If the K's of all column stories are not equal the moments at L and B can be determined approximately by the following method: Determine M_{AL} and M_{AB} as stated above. The moment M_{LA} is approximately equal to $\frac{1}{4}$ M_{AL} and M_{BA} is approximately equal to $\frac{1}{4}$ M_{AB}.

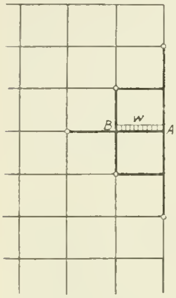
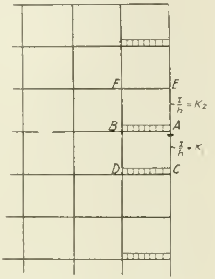


Fig. 7.



Loading for maximum moment in Column AC

Fig. 8.

From an inspection of the moment diagram of Figure 4 it is apparent that eccentric loads at M and at B will produce moments in the column just below A of the same sign as the moment produced by the load P at A. This being the case, for maximum moment just below A due to eccentric loads on the outside of the column, the colunm should be loaded as shown in Figure 5. If the K's of all column stories are equal and if the values of Pe for all loads are equal then the portion of M_{AB} due to the load at M is 1/30 Pe, that due to the load at B is 2/15 Pe and that due to the load at A is ½ Pe. The resultant moment $M_{AB} = 2/3$ Pe.

If there are external eccentric loads of equal moment at all stories, and if the K's of all column stories are equal, then the moment in the column at each girder is ½ Pe.

Eccentric Loads on External Column at Intermediate Floors; Connections of Girders to Column Rigid.—Figure 6 represents a frame of a building carrying an eccentric load at an intermediate floor of an external column. The connections of the girders to the column are rigid The force P produces a moment Pe which tends to rotate the point A. The point A is prevented from rotating by the resisting moment in the members AB, AF and AL. The values of the moments are $M_{AB} = Pe \frac{K_1}{K_1 + K_4 + K_{11}}$, $M_{AF} = \frac{K_4}{K_1 + K_4 + K_{11}}$, and $M_{AL} = Pe \frac{K_{11}}{K_1 + K_4 + K_{11}}$. If the K's of these members are equal $M_{AB} = M_{AF} = M_{AL} = 1/3$ Pe.

If the K's of all members of the frame are equal M_{LA} and M_{BA} equal 1/9 Pe and M_{LP}, M_{LM}, M_{BG}, and M_{BC} equal 1/18 Pe. It the K's of all members are not equal, approximate values of the moments can be determined as follows: Determine M_{AL} and M_{AB} as outlined above. $M_{LA} = 1/3\ M_{AL}$. $M_{LP} = M_{LA} \frac{K_2}{K_2 + K_{12}}$, $M_{LM} = M_{LA} \frac{K_{12}}{K_2 + K_{12}}$, and $M_{BA} = 1/3\ M_{AB}$. $M_{BG} = M_{BA} \frac{K_3}{K_3 + K_7}$, and $M_{BC} = M_{BA} \frac{K_7}{K_3 + K_7}$.

Moments in Columns Due to Unbalanced Loads on Rigidly Connected Girders.

Figure 7 represents a frame of a building having girders rigidly connected to the column. A girder at an intermediate story is loaded in the panel adjacent to the exterior column.

A preliminary study of Figure 7, by the slope deflection method*, shows that the four loaded spans of Figure 8 produce moment at A of the same sign. Loads on other girders will produce moments at A which are negligible or of opposite sign. Therefore when these four girders are loaded simultaneously, the moment at A is a maximum.

The loading of Figure 8, though possible, probably will not occur, but the greater part of the moment in the column is due to the loads on AB and CD alone. Thus, if the value of K is the same for all columns and girders, and if M represents the negative moment at the end of a fixed beam of like span and loading to AB, (in this case 1/12 Wl) then the loading of Figure 8 will produce a moment M_{AC} of .54 M; while loads on AB and CD only will produce a moment M_{AC} of .51 M, only 6 per cent less. Hence the latter case, which is likely to occur frequently, should be provided for. Figure 9 represents the moments in the columns and girders in a building for which the K's of all columns are equal, and the K's of all girders are equal, but not equal to the K's of the columns.

With loads on AB and CD, Figure 8, the middle curve of Figure 9 gives the maximum moment which occurs in the column just below A: the lower curve gives the moment in the column just above A. The upper curve gives the sum of the two moments or the negative moment in the girder at A. It is of interest that for the common proportions of members in concrete buildings, the value of M_{AC} is about .6 M.

The foregoing discussion clearly does not consider the many complications introduced by different moments of inertia among columns or girders, effect of column caps, brackets, haunches, etc. However the effect of the most important of these variations, that of different moments of inertia of columns may be closely approximated by use of Figure 9. That is, if columns AC and AE, Figure 8, have different values of K, use the average K of the two to find M_{AB} from Figure 9. This moment will be divided between columns AC and AE by making

$$M_{AC} = M_{AB}\left[\frac{4K_1 + K_2}{4K_1 + 4K_2}\right] \text{ and } M_{AE} = M_{AB} - M_{AC}$$

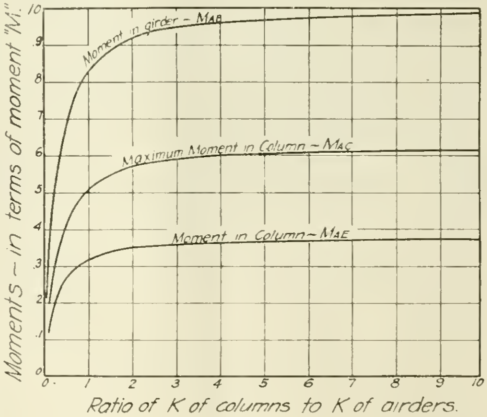


Fig. 9—Moment Distribution with Varying Stiffness of Columns and Girders.

With the proper interpretation this approximation also applies to columns at the roof level. In this case, however, the girder is restrained by only one column instead of two, as in the case of the other floors. The K to be used in finding M_{AB} from Figure 9 is therefore the average of K for the column below the roof level and the one above. Since the latter is zero the average K to be used is one-half the K for the column below the roof. The entire moment M_{AB} is, of course, transmitted to the column.

The moment distributions as found by these approximate methods are very close to the exact values, especially when the columns are stiffer than the girders.

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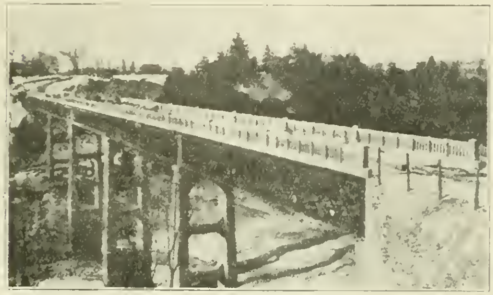
*Bulletin 108, Engineering Experiment Station, University of Illinois, by Wilson, Richart and Weiss.

108 Ft. Span Deck Girders for Highway Bridge Launched Without Falsework

Four concrete piers, about 100 ft. high, the use of second-hand latticed deck girders, and launching of these girders without false-work by means of a pilot, are the unusual features of the construction of a highway bridge at Tansey, Ontario. The following extracts from an article by A. W. Connor, Consulting Engineer, Toronto, in the Canadian Engineer of Jan. 8, 1920, give the salient features.

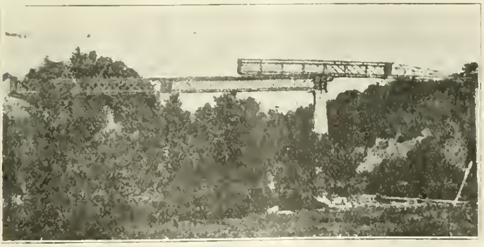
Tenders for a high level bridge were opened June 20, 1917, but the county council thought that they were too high, so action was delayed. Later, a proposal to use old intercolonial R. R. deck latticed girders that had recently been replaced by heavier structures, was submitted by Norman McLeod, Ltd., engineering contractors, Toronto, and was favorably considered. Plans and specifications for the structure now completed were then prepared, and the contract was awarded to Norman McLeod, Ltd., in August, 1917.



Tansley Bridge Almost Completed.

The superstructure consists of five deck latticed girders of 108-ft. span, 13 ft. 6 in. center to center, with concrete floor beams and a concrete floor slab 20 ft. wide from curb to curb. The curbs are 12 in. high by 10½ in. wide, and the concrete panel railing is 4 ft. high.

The subscructure consists of concrete abutments, with reinforced slab and counterfort wing walls and four concrete piers. The floor of the bridge is about 98 ft. above low water level and about 20 ft. below the level of Dundas St. on the west side. The cut for the west approach will have a maximum depth of about 6 ft. and the approach will have a grade of 5 per cent. This approach reaches Dundas St. by a reverse curve of 253 ft. radius.



Third Girder, with Pilot Attached, Ready to Be Moved Forward.

The old cut on the east side was utilized and filled to the new grade of 5 per cent. The maximum depth of fill was 35 ft. Some of the grading and the macadamizing of the approaches will not be completed until spring, but the bridge is now open for traffic.

The total length of the structure is 542.5 ft.; or, with approaches, 1,450 ft. It was designed for Class C loading of the Ontario Department of Highways (20-ton concentrated load).

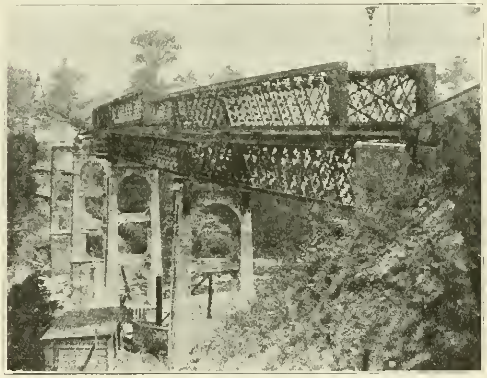
The contractor's plant included a Flory 5-ton steel cableway, about 1,000 ft. long, on wooden towers. This cableway was operated from the west bank. The mixer was a steam-driven 1-yd. Smith mixer, with overhead bins fed by a clam-shell bucket, and discharging into 1-yd. hopper bottom buckets under the cableway.

The steel railway girders were unloaded at the Tansley station. They are 108 ft. long, 9 ft. 8 in. deep (back to back of channels), and weigh about 20 tons each. The chords consist of two 12-in. channels and 24-in. cover plates. The web members consist of a double system of angles and bars, forming 5-ft. panels. Samples of damaged members of girders that had been subjected to similar service showed satisfactory strength. Under a uniform live load of 100 lb. per square foot, the maximum stress per square inch was found to be 13,100 lb.

The girders were hauled from the station to the site lying flat on house-moving trucks placed at about the quarter points. They were moved by a team with block and tackle. They were set up on the west bank and the new brace frames and laterals were then assembled and riveted.

The lower part of the piers were 10 by 20 ft. without batter, and the upper half was battered to 6 ft. to 16 ft. 8 in., with large openings. The upper half of the pier was cast in three sections, breaking above the struts. The piers were reinforced against temperature stresses only, except the struts and knee-braces, which were heavily reinforced against wind stress.

The launching of the girders without false-work was probably the most interesting feature of the work. A pilot (or pair of triangular trusses 60 ft. long, with cross bracing) was used to carry each girder in turn as they were placed, and was securely tied to the shoe plates. The pilot was handled by the cableway and connected as soon as the girder was out far enough to allow the end of the pilot to rest upon the next pier.



Third Girder Being Placed; Fourth Girder Follows Closely.

A pair of 30-ton steel rollers were placed on the forward pier to reduce friction, consequently reducing strain on the piers. The girders were moved on greased rails, with shoe plates bolted under the girders, with plank between to take up the baring of the rivet heads. The motive power was supplied by the carriage of the cableway, through a series of block and tackle.

The first girder was pulled from the west abutment by passing steel cable around same, through the weep holes, the others being pulled from the forward end of the last girder placed.

Timbers (12 by 12 in.) were placed on top of each pier to a height of about 6 ft., which reduced the slope upon which each girder moved off the preceding one. After a girder had been moved into position, it was jacked down to its final level. The next was then brought down, run out over those in place, and jacked down in similar manner. In order to provide an even bearing for the masonry plates under the uncertain camber of the girders under load, temporary bearing was taken on a 4-in. strip of steel and was afterwards grouted.

As soon as the last of the girders has passed over the west span, the form-work for the deck was commenced. The deck consists of reinforced concrete floor beams on panel points 5 ft. center to center, with a 7½-in. slab. The girders are at 13 ft. 6 in. centers, while the deck is 20 ft. clear of curbs. The curbs were cast with the deck, leaving a chase on top to take the concrete pre-cast panels of the railing. These panels were 2½ in. wide. Reinforcing rods for posts were left projecting. The panels were hauled up by the cableway and were set up in position, forms for posts and upper rails were clamped around them, and they were then concreted. At the ends of the girders, expansion was provided for by the panels and rails sliding in slots in the posts. In the floor, a steel plate with two angles was used.

The work was done on a cost-plus basis, and the total expenditure was about $110,000. The Ontario Department of Highways will pay 60 per cent of the cost. W. A. McLean, deputy minister of the department, appointed A. Sedgewick, and later Jas A. Bell, to represent the provincial government on the work. As previously stated, Norman McLeod, Ltd., were the contractors. Bowman & Connor, consulting engineers, Toronto. were the engineers for the county. The contractors were represented on the work by R. F. Smith as resident engineer.

Light Weight Aggregate Tests by Bureau of Standards

Investigations of light weight aggregates for concrete ships were continued during the past year by the U. S. Bureau of Standards. Twelve burnt clay aggregates were tested, these tests aiding in the selection of a light weight aggregate by the Emergency Fleet Corporation for use in concrete ships. The aggregate produced commercially was a light-weight burnt clay made by "puffing" or "bloating" a clay or shale in a stationary brick kiln or a rotary cement kiln.

The tests of the best varieties of this aggregate, according to the last annual report of the Director of the Bureau, showed that it would give a satisfactory strength (from 4,700 to 5,700 lb. per square inch at 28 days) when used in a 1:⅔:1⅓ mix and would give a concrete weighing from 110 to 115 lb. per cubic foot (about three-fourths as much as ordinary concrete). Tests were also made using these light-weight aggregates in 1:1:1 and 1:1:2 mixes. During the investigation several varieties of slag were tested and generally gave satisfactory strength results, but did not produce so light a concrete. Coke as an aggregate gave light concrete, but was slightly inferior in strength. Seven varieties of vesicular, basaltic, or volcanic rocks were tested for this purpose. In general, these give satisfactory strength, but produced slightly heavier concrete than the clay aggregates. Several other rock aggregates were tested.

Permeability tests were made comparing several of the clay aggregate concretes, with sand-gravel concrete of the same mix, and, although the tests were limited and not conclusive, they indicate that the concrete made of clay aggregates is at least as impermeable to water as that made with sand and gravel. Absorption tests show that clay-aggregate concrete is more absorptive than sand-gravel concrete. For a 1:1:2 mix, sand-gravel concrete showed 8 to 10 per cent absorption in terms of dry weight, while clay-aggregate concrete gave 12 to 18 per cent. Tests showed that the modulus of elasticity of aggregate concretes, with sand-gravel concrete of the same as that of concrete made of sand and gravel.

Acceleration of Hardening of Concrete by Steam.—Experiments were made during the past year by the U. S. Bureau of Standards to determine how strong a 1:2:4 concrete could be produced in 48 hours, using steam applied internally and externally to the mass of concrete. Twelve-inch cubes of concrete were subjected to the following methods of curing: Indoor air, external steam, steam flowing through embedded, perforated pipes, steam flowing through nonperforated pipes. Use of perforated pipes proved impractical, due to clogging of the pipes. All three methods of steam curing, according to the recently issued annual report of the Director of the Bureau, gave practically the same strength at the end of 48 hours. This strength was from 200 to 400 per cent of the strength of air cured concrete of the same age, depending upon whether cured indoors or outdoors, and was about equal to the strength of air-cured concrete 7 days old.

Pressure of Concrete in Forms

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Generally, no attempt is made to design concrete forms, the dimensions and spacing of the lagging, studs, bracing and tie rods usually being left to the superintendent or carpenter-foreman. While, admittedly, other factors may affect the design of the forms, such as wear, ease of handling, etc., the concrete pressure is the most important factor and the practical judgment of the superintendent or foreman may well be tempered by a careful study of the form pressures.

It is undoubtedly a very difficult matter to attempt to clothe in mathematical language the behavior of concrete as it passes from the fluid to the solid state. Several conditions are given, however, and experiments have furnished certain constants all of which aid in formulating an expression for the concrete pressure. This expression is necessarily an empiric one, but it should serve to found a safe method of concrete form design. In addition, the analysis may prove a starting point for further investigation, both theoretical and experimental. Pending the qualifying results of such further work, the formulas below should prove a valuable aid in effecting a consistent design of the forms and bringing attention to bear upon the importance of applying some form of analysis to the proper construction of the concrete form. To aid in the application of the equations formed below, some tables have been prepared which should simplify the work of computing the pressures.

The lateral pressure of concrete is a function, not only of the head of concrete, but also of the time elapsed since the concrete was mixed. The pressure increases as the head of concrete increases and decreases as the time increases.

Experiments seem to show that the pressure follows a hydrostatic law ($p = wh$) for a short while, then rapidly diminishes, becoming infinitesimal. This behaviour suggests that an exponential expression would most likely satisfy these conditions and accordingly an empiric expression of the form

$$p = whe^{-kt^2} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

is assumed,[*] where p is the unit pressure on a vertical surface at a given point h below the top of the concrete in pounds per square foot; h is the head of concrete in feet; e is the base of natural logarithms and k is a parameter to be determined below; t is the time elapsed since the point at "h" was poured, in hours.

To determine the value of the parameter k, it is necessary to employ some experimental data. Major F. R. Shunk performed a fairly exhaustive series of concrete pressure experiments, a resume of which is given in Engineering News, Vol. 62, p. 288. The deviation of the concrete pressure curve from a linear hydrostatic law (i. e. $p = wh$) he found to occur after a time T had elapsed, where

$$T = c + 150/R \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

In this expression T is the time in minutes, c a constant (see table) depending upon the temperature of the mix; R is the rate of pouring, i. e., the rate at which the level of concrete is rising; or expressed mathematically, $R = dh/dt$

Expressing (2) in the units adopted above

$$T' = t_o = C + 2{,}5/R \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

The values of C may be taken from the table.

To determine upon a fixed point for the deviation, let it be arbitrarily assumed that the actual pressure is not observed to vary from the fluid law until this variation amounts to 5 per cent of the fluid law. While this is a broad assumption, it appears to be a reasonable one and it can be shown that slight changes in the per cent assumed does not affect, materially, the final result.

Introducing this condition, then, at a time t_o the actual pressure is found to be 95 per cent of the fluid, as given by the law $p = wh$. Referring to (1)

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[*] It may be possible to show rigorously, by the principles of statical mechanics, that this is the most logical form of an expression to define the action of a material like concrete in the form. Such is, however, rightly the province of the mathematical physicist. The above expression is chosen solely as a matter of expedience. It seems to follow the law of concrete pressure (if there be such a law) and lends itself well to analysis. Note a similar form of expression employed to give the intensity of transmitted vertical pressure in a granular material in the "Second Progress Report of the Special Committee to Report on Stresses in Railroad Track." Am. Soc. C. E., Nov. 26, 1919, p. 123.

$$p = whe^{-kt_0^2} = 0.95\ wh.$$
$$e^{-kt} = 19/20, \text{ or}$$
$$e^{kt} = 20/19$$

Taking the logarithm to the base e of both sides, and solving for k

$$k = \frac{1}{t_0^2} \log.\ (20/19) \ldots\ldots\ldots (4)$$

Note that $\log_e(20/19) = 0.0513$.

Using the value of k in (4) and applying to (1), we get

$$p = K\ wh \ldots\ldots\ldots (5)$$

where

$$K = \frac{1}{\left(\frac{20}{19}\right)^{t^2/t_0^2}}$$

The values of K for a series of values of the ratio t/t_0 are given in the table accompanying.

To determine the values of the arguments to be used in any given problem note that the time t_0 is to be obtained from (3). The temperature of the concrete may be taken from that of the air. (This may be subject to dispute, but note that it is on the safe side.) With the capacity of the form known, and the rate of the mixer, it is easy to determine how fast the concrete will rise in the form (R) and how long it will take the concrete to fill the form (t). The example given at the end of this article will aid in applying these points.

Since the pressure p is a function of the time as well as head it is interesting to determine at what point there will be a maximum pressure. With R the rate at which the concrete rises, and t the time to reach a head h,

$$h = Rt \ldots\ldots\ldots (6)$$

Substitute this in (1) and take the derivative of this expression with respect to t. Equating to zero and solving for t

$$t^2 = 1/2k.$$

Referring back to (4) and using the value of the logarithm of 20/19 to the base e, there is found

$$t = 3.1\ t_0 \ldots\ldots\ldots (7)$$

as the elapsed time for a maximum pressure. From (6) and (3) the head h is found to be

$$h = 3.1\ CR + 7.8 \ldots\ldots\ldots (8)$$

It is important to know, of course, the pressure over a given area, of height h. Calculus may be employed to get an expression for this total pressure. At any point x above the bottom of the form, the pressure, over a height dx is, from (1)

$$p = w(h-x)e^{-k(h-x)^2/R^2}dx$$

since the time t for any x is, from (6) above $t = (h-x)/R$. Place $h-x = u$ and $k/R^2 = a^2$. The total pressure is then

$$P = w\int_0^h ue^{-a^2u^2}du$$

Integrating the expression, and replacing the substitutions, there is finally,

$$P = A\ wh^2/2$$

where

$$A = \frac{1-e^{-kt^2}}{kt^2}$$

The value of A is given in the table accompanying.

TABLES FOR LATERAL CONCRETE PRESSURES.

Temperature (Fahrenheit).	c	C	Temperature (Fahrenheit).	c	C
80	20	0.35	55	42	.70
70	25	.42	50	50	.83
60	35	.58	40	70	1.17

t/t_0	K	A	t/t_0	K	A
0	1.00	1.00	5	.28	.56
¼	1.00	1.00	6	.16	.46
½	.99	.99	7	.08	.37
¾	.97	.99	8	.04	.29
1	.95	.97	9	.02	.24
1½	.89	.94	10	.01	.19
2	.81	.90	15	..	.09
3	.63	.80	20	.	.05
4	.44	.68	Inf.	0	0

Examples.—To illustrate the application of the above let us take a few examples. (1) A form 30 ft. long, 2 ft. wide and 15 ft. high is to be poured with a mixer of 10 yd. capacity per hour. The temperature is 70°.

The capacity of the form is 33⅓ yd. and it will take 3⅓ hours to fill it, the concrete rising in the form at the rate of 4.5 ft. per hour. From the table, with the temperature 70°, $C = 0.42$ and from (3)

$$t_0 = 2.22$$

$t/t_0 = 1.5$ and $K = 0.89$; $A = 0.94$. Assume that the concrete weighs 150 lb. per cubic foot. The pressure at the base is

$$p = 0.89\ wh = 133\ h$$

corresponding to an average fluid pressure of 133 lb. per cubic foot. The total pressure on the form is

$$P = 0.94\ wh^2/2 = 141\ wh^2/2$$

corresponding here to a fluid weighing 141 lb. per cubic foot. In designing the forms these intensities will be used in determining the proper dimensions of the panels and bracing.

(2) A retaining wall section containing 10 yd. per horizontal foot is to be poured by a mixer of 20 yd. per hour capacity. A pour of 10 hours constitutes a day's work. R is here 2 ft. per hour. The same temperature is assumed.

$$t_0 = 0.42 + 2/2.5 = 1.22.$$

Since the total t is 10

$$t/t_0 = 8.2.$$

This is greater than the "critical" value of 3.1 above, and hence the maximum pressure will occur at the point from (8)

$$h = 0.42 \times 2 \times 3.1 + 7.8 = 10.5 \text{ ft.}$$

For the above value of the critical ratio $K = 0.6$ and the pressure at the point 10.5 is 945 lb. per square foot. Any panel in the form between the level 10.5 ft. from the top and the bottom must be prepared to carry this maximum unit pressure. Note that at the bottom, for the value of the ratio 8.2, $K = 0.03$ and $A = 0.28$, so that the bottom pressure at the end of the day's run is only 90 lb. per square foot, and the total pressure on the 20 ft. of form is 8,400 lb. The upper 10 ft. of form will, of course carry the maximum pressure, and here since the ratio is one-half of the above, or 4.1. $A = 0.67$ and

$$P = 5{,}000 \text{ lb.}$$

For smaller strips, the time to fill the strip is found, thence the ratio t/t_0, and finally the coefficient A from the table.

Throughout the above work a unit length of 1 ft. of form is assumed.

In concluding it should be emphasized again that the attempt to formulate concrete behavior is one solely of expedience. It seems unnecessarily harsh to assume that concrete is a fluid throughout the pour and rather rash to adopt another expedient that the concrete pressure after a given interval is nil. Not to attempt any analysis of the concrete pressure leads to uneconomical forms, which in view of the present prices of both labor and material, is a most unhappy consequence.

Paving Mixer in Building Construction

Concrete floors for the new plant of the Cadillac Motors Co. at Detroit, Mich., were constructed with a paving mixer, which was raised from story to story as the work progressed. The mixer, a 1918 Model Smith paver, equipped with a swivel chute, was first utilized for pouring all the footings of the columns of the building. The footings of each column were 8 ft. wide by 8 ft. long by approximately 8 ft. deep. The paver was placed between the rows and poured first on one side and then on the other side by merely swinging the chute. After the paver had completed this work it was driven under its own power to another spot where it was put to work pouring the fence walls on one of the large tunnels. It was then taken into the building proper after it had begun to rise above the ground and was used for grouting in the floors. It was also used for pouring all of the floor slabs. As the work progressed it was used on each floor in turn. It was taken from one story to the next by a crane which hooked onto two cables wrapped around the machine and swung it up to the next floor. The Du Pont Engineering Co. is the contractor for the Cadillac Plant.

Reinforced Concrete Investigations of U. S. Bureau of Standards

A large portion of the investigational work in reinforced concrete of the U. S. Bureau of Standards during the fiscal year ending June 30, 1919, was carried out for the Concrete Ship Section of the Emergency Fleet Corporation. This investigational work is outlined in the recently issned report of the Director of the Bureau of Standards, from which the following notes have been abstracted

Corrosion and Bond Tests of Reinforcing Steel.—Corrosion tests were made to obtain information relative to the importance of corrosion of the reinforcement in concrete ships and the methods of preventing or mitigating corrosion of the reinforcement. About 20 proprietary coatings, including paints and asphalts, were used as protective coatings, and salt-spray tests were made to determine their effectiveness. Many of the coatings were found to be effective in preventing corrosion, but to have serious effect in reducing the bond strength of steel when embedded in concrete. Pull-out tests of specimens, consisting of steel bars coated with the protective coatings, were made on about 400 specimens. These tests showed that practically all coatings, even including metallic coatings such as zinc, had a deleterious effect on the bond strength (the resistance to slipping through the concrete) of bars embedded in concrete.

Repeated Reversal of Load on Reinforced-Concrete Beams.—The tests on double-reinforced-concrete beams loaded in alternate directions have been carried further. Four beams have been tested to failure, and in all cases failure was by tension in the steel. One beam which has had 2,000,000 applications of the design load shows no indication of the approach of failure. In one beam there was a large amount of slip of a reinforcing bar before failure occurred. Within the limit of these tests there is no indication that the strength of a doubly reinforced-concrete beam (reinforced for bending in opposite directions) is determined by the properties of the concrete, if the ordinary requirements of design are met, unless it be that of the bond streets. The abrasion of the concrete at the edges of cracks in reinforced-concrete ships was considered as a possible danger, and the tests were initiated to obtain information on this subject. There is no indication that this is a real danger. Not all the tests originally planned have been completed. The danger of slipping of bars either where they are lapped at the center of the span or where at the end of the beam they do not have anchorage by hooking of the bars is one which should be investigated and on which certain of the tests already planned should give information.

Leakage of Water Through Cracks in Reinforced-concrete Shell.—Early in the investigation of shearing strength of reinforced-concrete beams it was found that cracks were likely to form when shearing stresses were considerably lower than those which it seemed necessary to use in the design of concrete ships; yet it was not known whether these cracks were such as would permit leakage of water through them or not. Tests were made in which hollow beams were loaded in such a way as to cause diagonal tension cracks in the side walls at the same time that the beam was filled with water, which was maintained under pressure varying in head from 15 to 30 ft. These tests indicated that the smallest crack which could be detected, say, 0.001 in. or less in width, would permit the passage of enough water to cause a moist surface on the outside around the crack. As the crack width increased the leakage increased rapidly, provided that time was not given for the closing up of cracks by the deposit of sediment of any kind. When the crack was 0.01 in. wide water spurted clear of the outer surface of the beam. When the beam was allowed to stand overnight with the pressure head and the load maintained the leakage was decreased markedly. This was probably due to the deposit of a substance which helped to fill up the cracks. Further indication of this was shown by the appearance of efflorescence on the surface of the beam in the neighborhood of the cracks. If the cracks had been very small at the time of their formation and had developed very slowly, it is possible that the silting would have kept up with the opening of the cracks and that leakage would not have occurred. Apparently this is what has happened with some of the concrete ships and barges which are afloat. An inspection made on a concrete ship which had been in the water about a year showed the presence of cracks which were large enough to cause leakage under the conditions to which these test beams were subjected. However, there was no leakage, although the cracks were below the water line, and apparently there had been none. There was efflorescence apparent at cracks on the inside of the hull, indicating that the process of silting had been taking place.

Sheer and Compression in Reinforced-concrete Beams.—These tests were begun as a part of the study of reinforced concrete in adapting it to use for the construction of concrete ships. One of the first serious difficulties in the designing of concrete ships was that of getting sufficient strength to prevent cracks forming diagonally in the vertical sides of a ship of practicable weight. Using the methods ordinarily employed in reinforced-concrete design, a shell thickness of at least 15 in. would have been required instead of the 4 in. used in the 3,500-ton cargo ship. Tests of large reinforced-concrete beams were started to make certain that no mistake was being made in using a 4-in. shell. These first tests were made on (a) beams 4 ft. 4 in. deep and 18 ft. 6 in. long; (b) one beam 10 ft. deep and 22 ft. long; and (c) specimen ship frames of full-sized cross section and 20-ft. span. The frames were cut off at a point corresponding to the point of inflection, or 4 ft. 6 in. above the top of the keel. The tests were made in the 10,000,000-lb. testing machine at the Pittsburgh laboratory of the Bureau of Standards.

For the beams the load was applied at the center of the span upon the upper flange. The beams were supported at each end on a steel-plate girder. The beam, 10 ft. deep, was first loaded 40 times with 640,000 lb., which was four times as much as the maximum which the standards of the joint committee on concrete and reinforced concrete would have allowed as its working load. The widest crack at the first application of this load was 0.013 in., and with 40 repetitions of the load, there was no appreciable increase in the widths of the cracks. The beam was then inverted and load was applied in the opposite direction, causing failure at 1,363,000 lb., or nine times as much as the joint committee standards for reinforced-concrete design would have allowed as a working load.

The ship frames were tested by applying first only a vertical load and adding later a horizontal load at the sides corresponding to the horizontal water pressure on the sides of the ship. It was found that the strength here was about eight times as great as the joint committee recommendations allowed for the working load, also that the shear due to the horizontal forces reduced the stresses set up by the shear due to the vertical forces; in other words, that the horizontal water pressure would reduce the stresses caused by the vertical shearing forces on the frame.

These tests made it possible to design with confidence for shear in reinforced-concrete ships, using working stresses much higher than those which are recognized by the final report of the joint committee. In effect, the joint committee report limits the amount of web reinforcement to about three-fourths of 1 per cent, while these tests show that for deep beams a much larger amount of reinforcement would be effective. Apparently the main reason for the higher shearing strengths found in these tests is the larger percentage of web reinforcement which may be used effectively in deep beams where the web bars have much better chance for anchorage than in shallow beams.

After these preliminary tests were completed a more nearly exhaustive investigation was initiated at Lehigh University, Bethlehem, Pa., for the Concrete Ship Section of the Emergency Fleet Corporation.

In the economical use of building materials the importance of using higher shearing stresses in reinforced-concrete beams has been recognized by many. The results of the tests made for the Concrete Ship Section were so significant in this direction that the Bureau of Standards continued the investigation after the program of tests as related to concrete ships was completed. In all 172 beams have been tested, and the results have been quite fully worked up, giving data for a technologic paper which should be of much importance to the reinforced-concrete industry.

The conclusion from these tests is that not only working stresses in shear may properly be increased, but that they may be increased to such an extent that other features of the design become the controlling features. In order to make use of the high shearing stresses permitted, compressive stresses would be increased beyond all present reasonable values. This led to the making of tests to determine if an increase in compressive stresses was permissible. These tests were only four in number and not sufficient to afford a basis for a general conclusion, but, so far as they go, they indicate that higher working stresses in compression than are now generally recognized could be used with safety. It is important that further tests of this kind be made.

Reinforcement for Concrete Slabs.—There has been much uncertainty as to the relative economies of reinforcing slabs with (a) bars in the direction of the span, (b) bars making some angle with the span, and (c) expanded metal. Twenty-six slabs, 4 in. thick were tested, in each of which one of the three methods of reinforcing described above was used. The results as they stand indicate that the largest amount of steel is required in the case in which the bars are placed diagonally with the span, and that as regards quantity of steel required there is a slight advantage for expanded metal over the use of bars in the direction of the span. However, certain conditions of the tests make it important that more tests be made before this question is considered to be settled.

Length of Lap Required for Reinforcing Bars. Tests were made to determine how great a length of lap is necessary for cases in which the reinforcing bars used are shorter than the span and are spliced by lapping them in the center of the span. Four beams were made in this series, and the indication from the test results is that for this size of bar (one-half inch round) a lap of about 50 diameters is required. The concrete used in these beams had a strength of about 5,000 lb. per square inch, and it is to be expected that with a leaner concrete a larger lap would be necessary. Some information from tests in which expanded-metal reinforcement was lapped in the same way is available. As to quantity of steel required for the lap, this indicates a slight advantage in favor of expanded metal.

Value of Brackets and Haunches in Flanges.—For purposes of architectural effect, or for increasing the strength, connections between columns and beams are frequently provided with brackets. This development sometimes takes the form of an arch construction. However, in the design little attempt is usually made to determine how much strength is added by the presence of the haunch, and usually advantage is taken of only a portion of the value of the haunch or bracket. In the design of reinforced-concrete ships the strength value of such brackets is of much importance. To obtain information on this subject, a series of tests was made, including as test specimens eight reinforced-concrete frames having a span of 14 ft., a height of 7 ft., and brackets ranging from no bracket to one so large as to give the appearance of an arch. These tests indicated that the brackets had much more value in strengthening the frames than that for which allowance is usually made in the design. The results are of much importance, since the weight of the frames in a concrete ship can be reduced materially by taking full account of the strength added by the brackets in the frames. If the results are adapted to general design in reinforced concrete, they will have an important bearing on the reinforced-concrete industries where such structures are involved.

Shrinkage of Concrete in Setting as Related to Concrete-ship Construction.—It is recognized that shrinkage of concrete occurs during setting. In one of the barges constructed by the Emergency Fleet Corporation for the Inland Waterways Commission a series of careful measurements was made in the effort to determine why more frequent and larger cracks occurred in this barge than occurred in the others. While the effort was not entirely successful, the measurements did show that there was an elongation and shortening of the barge which corresponded closely to even the slightest rise and fall of temperature. With any rise in temperature the cracks began to close, while with a decrease in temperature the cracks opened. The largest crack present was less than 0.01 in., and although the barge was not loaded the results of examinations of concrete ships which have been in service indicate that a deposit of silt or efflorescence will prevent leakage through cracks in this size.

Portland Cement Production and Prices in 1919

Preliminary estimates compiled by the U. S. Geological Survey indicate that the production and shipments of Portland cement in 1919 increased 13 and 21 per cent, respectively, over those in 1918 and that the stocks decreased 52 per cent, so that at the end of 1919 less than 5,000,000 bbl. of Portland cement was in stock at the mills. The Portland cement industry was set back considerably in 1918, when war restrictions reduced the shipments from the 90,703,474 bbl. shipped in 1917 to 70,915,508 bbl., but it is now regaining its lost ground. Early in 1919 the business was even poorer than in 1918, and practically all the increase reported was made during the latter part of 1919, so that 1920 started with favorable prospects for the cement industry. During 1919 the shipments from some mills were limited by the lack of freight cars. The increase in the value of the cement shipped in 1919 over that shipped in 1918 was about 28 per cent.

The shipments of Portland cement in 1919 amounted to 85,485,000 bbl. valued at $144,461,000; the production amounted to 80,287,000 bbl.; and the stocks at the mills at the end of the year amounted to 4,976,000 bbl.

One new plant produced Portland cement in 1919 the Indiana Portland Cement Co., at Greencastle, Ind. The total number of plants that produced cement in 1919 was 110, and the total number of plants that shipped cement was 113. The average factory price per barrel for Portland cement in bulk in individual states in 1919 ranged from $1.57 in Kansas to $2.03 in Utah. The average factory price for the whole country in 1919 was $1.69, an increase of only 6 per cent over 1918.

The exports of hydraulic cement from the United States in 1919 amounted to 2,463,689 bbl., valued at $7,516,019, or $3.05 per barrel, increases of about 9.27 and 16 per cent, respectively, over 1918.

The following table shows the estimated output of Portland cement in the United States in 1919 and the actual figures for 1918 by districts:

District.	1918, barrels.	1919, barrels.	Pctg. of change in 1919.	Avg. factory price per bbl in 1919.	Pctg. of change in price in 1919.
Lehigh district (eastern Pa. and N. J.):					
Shipments	19,351,123	23,630,000	+22	$1.63	+7
Production	19,791,820	22,614,000	+15	....	....
Stock	2,512,123	1,546,000	—39	....	....
New York State:					
Shipments	1,074,159	4,274,000	+ 5	1.66	+ 3
Production	4,095,588	4,140,000	+ 1	....	....
Stock	832,271	638,000	—23	....	....
Ohio and western Pennsylvania:					
Shipments	6,231,702	7,164,000	+15	1.63	+ 6
Production	6,439,179	6,726,000	+ 5	....	....
Stock	845,373	375,000	—56	....	....
Michigan and northeastern Indiana:					
Shipments	4,183,260	5,421,000	+30	1.70	+ 2
Production	4,106,467	4,990,000	+22	....	....
Stock	790,495	372,000	—53	....	....
Southern Indiana and Kentucky:					
Shipments	1,960,109	2,644,000	+36	1.65	+ 2
Production	1,609,475	2,455,000	+50	....	....
Stock	246,242	55,000	—69	....	....
Illinois and northwestern Indiana:					
Shipments	7,894,542	9,884,000	+25	1.62	+ 6
Production	7,169,038	8,945,000	+25	....	....
Stock	1,088,775	218,000	—80	....	....
Maryland, Virginia and West Virginia:					
Shipments	2,308,193	2,628,000	+39	1.73	+ 7
Production	2,281,629	2,462,000	+ 8	....	....
Stock	268,384	108,000	—60	....	....
Tennessee, Alabama and Georgia:					
Shipments	3,092,425	2,780,000	—10	1.69	+11
Production	2,990,734	2,727,000	— 9	....	....
Stock	118,988	69,000	—42	....	....
Iowa, Missouri and Minnesota:					
Shipments	8,712,597	11,575,000	+33	1.67	+ 2
Production	9,478,051	10,102,000	+ 7	....	....
Stock	1,937,902	267,000	—86	....	....
Nebraska,* Kansas, Oklahoma and central Texas:					
Shipments	5,365,848	6,387,000	+19	1.70	+ 1
Production	5,370,181	6,184,000	+15	....	....
Stock	654,876	419,000	—15	....	....
Rocky Mountain States (Colorado, Utah, Montana and western Texas):					
Shipments	2,175,874	2,972,000	+37	2.00	+ 8
Production	2,288,953	2,772,000	+21	....	....
Stock	375,042	213,000	—43	....	....
Pacific Coast States (California, Washington and Oregon):					
Shipments	5,565,676	6,126,000	+10	1.98	+14
Production	5,550,548	6,170,000	+11	....	....
Stock	783,479	696,000	—11	....	....
Shipments	70,915,508	85,485,000	+21	$1.69	+ 6

*No output in 1918.

Effect of Rodding Concrete

In a letter to the editor in the Jan. 8 issue of the Canadian Engineer, Mr. F. E. Giesecke, Professor of Architectural Engineering, University of Texas, gives some interesting and valuable information as to the effect of "rodding" concrete. Abstracts from his letter follow:

For some time the Engineering Division of the Bureau of Economic Geology and Technology of the University of Texas has been devoting considerable attention to an investigation relating to improvement in concrete construction and based on the following assumptions:

(a) The strength of concrete is a function of the cement-concrete ratio, other factors remaining constant.

(b) For a given set of conditions there is a fairly definite water-concrete ratio which assures the greatest strength of the concrete.

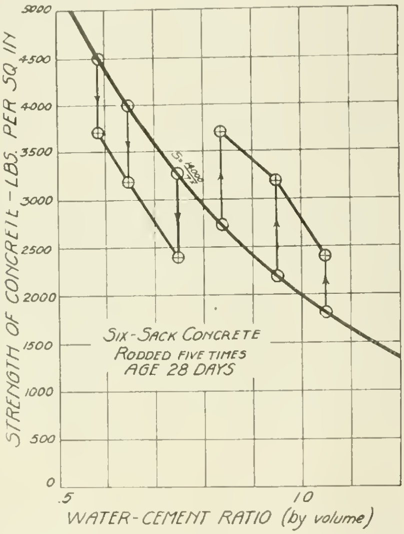

Fig. 1—Comparison of Prof. Abrams' Curve with Strengths of Rodded Concrete. Water-Cement Ratios Based on Quantity of Water in Concrete Before and After Rodding.

(c) In practical concrete construction it is generally necessary, or at least often highly desirable, to use more mixing water than the optimum quantity, in order to produce a concrete which is sufficiently fluid to be handled advantageously and which will flow readily into the forms and between and around the reinforcing steel—even though such concrete is weaker than it would be if less water had been used in its preparation.

During the course of our experiments it was found that it was possible to prepare concrete with considerably more than the optimum quantity of water, deposit this concrete in the molds in a manner similar to that used in actual concrete construction, then "rod" the concrete, and finally secure a material which is fully as strong as it would have been had only the optimum quantity of water been used.

In other words, by this method of producing concrete it is possible to secure the advantage of economic handling and thorough filling of forms and coating of reinforcing steel, which is characteristic of concrete containing excess mixing water, and also the advantage of maximum strength, which is characteristic of concrete prepared with the optimum quantity of mixing water.

During the course of our investigation Prof. Abrams published his discovery that the strength of concrete can be expressed as a function of the water-cement ratio; the compressive strength of a 28-day concrete, prepared of good materials, being approximately $14{,}000 / 7^x$ lb. per square inch.

Prof. Abrams' value was accepted as the best available basis for the comparison of the strength of rodded and unrodded concrete because Prof. Abrams had made a sufficient number of tests to convince us of the accuracy of his work, and because those of our tests which were made with unrodded concrete agreed well with Prof. Abrams' results.

Since the strengths of our rodded concrete were so much in excess of those shown by Prof. Abrams' curve, it was suggested that we repeat our tests and determine the quantity of water expelled from the concrete by the rodding, and to plot the strength against the water remaining in the concrete to see whether Prof. Abrams' expression would then agree with our results.

This was done in connection with a series of tests designed primarily to determine how the strength of "rodded" concrete varies with the cement-concrete ratio and with the maximum size of the coarse aggregate, other factors remaining constant.

The cement-concrete ratio is expressed in terms of the number of sacks of cement incorporated in a cubic yard of concrete; the six-sack concrete, for example, refers to concrete which, in its final condition, contains cement at the rate of six sacks of 94 lb. of cement per cubic yard of concrete.

In the series referred to, three cement-concrete ratios, namely, 4-sack, 6-sack, and 8-sack; three maximum sizes of the coarse aggregate, namely, ½ in., 1¼ in. and 2½ in.; and four water-concrete ratios; six specimens were made of each kind, or 216 specimens in all, were used.

The results of the 28-day tests of the 6-sack, 1¼ in. maximum size aggregate, are shown in Fig. 1 for three water-cement ratios; it appears from this figure that, for this particular concrete, the values shown by Prof. Abrams' curve are about 28 per cent too low when the water-cement ratio is based on the quantity of water used in mixing the concrete, and about 26 per cent too high when the ratio is based on the quantity of water remaining in the concrete after rodding.

Our 28-day results for the 4-sack and 8-sack concretes are very similar to those for the 6-sack shown here.

Figure 2 shows Prof. Abrams' curve and the results of three parallel groups of tests of rodded and unrodded concrete made by us. The average strength of our nine unrodded specimens made at three different times, widely separated, is 1,811 lb. and falls almost exactly on Prof. Abrams' curve; this shows that our materials and methods must be very similar to those employed by Prof. Abrams.

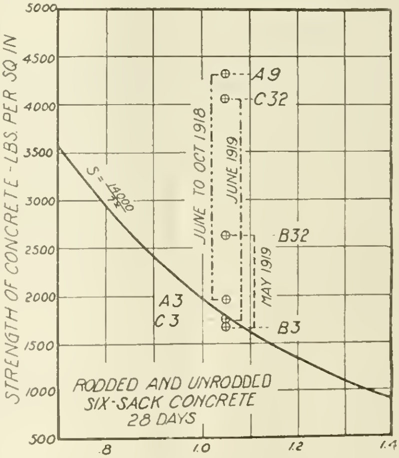

Fig. 2—Comparison of Strengths of Unrodded and Rodded Concrete with Each Other and with Prof. Abrams' Curve.

Since our results with unrodded concrete agreed with Prof. Abrams' curve near the middle of that curve and for that type of concrete which is most generally used in reinforced concrete work, and since Prof. Abrams concluded from his extensive tests that "it is seen that for given concrete materials the strength depends on only one factor—the ratio of water to cement," I see no reason for a further checking of Prof. Abrams' curve.

Group A of Fig. 2 consists of three unrodded and nine rodded specimens, these results were obtained June to October, 1918.

Group B consists of three unrodded and 32 rodded specimens; these results were obtained in May, 1919, and have not et been published.

Group C consists of three unrodded and 32 rodded specimens: these results were obtained in June, 1919.

The reason why the strengths of the Group B rodded specimens are so much lower than those of Group C, is that in the case of Group B the water which was worked out of the specimens by rodding was allowed to remain on the specimens so that the same were practically standing under water, whereas, with Group C, concrete was added as the rodding compacted the specimens, so that the molds were always practically full of concrete and the water which was rodded out of the specimens could run off over the tops of the molds, our molds being practically water-tight.

Effect of Oil on Untreated Concrete Storage Tanks

During the past year three more series of tests were conducted by the U. S. Bureau of Standards to determine the limitations of untreated concrete tanks for storage of oils. The results of the tests are summarized as follows in the recently issued report of the Director of the Bureau for the fiscal year ending June 30, 1919:

Series I consists of eighteen 1:2:4 concrete tanks in which were stored 11 mineral oils with gravities varying from 0.742 to 0.959—that is, from commercial motor gasoline to a very viscous residiuum oil—5 vegetable oils, and 2 animal oils. In each tank were placed three 6 by 12 in. concrete cylinders, to be broken after an exposure to the various oils. This series was started to determine the volumetric loss of oil due to absorption and penetration of the oils, but it was found that the physical properties of the oils and the temperature changes played such an important part in determining accurately the loss that these tanks were kept under test as qualitative rather than quantitative tests.

After a year's exposure to the various oils, the concrete of the tanks and cylinders is apparently unaffected, with but two exceptions. The surfaces of the tanks containing cocoanut and lard oils have been attacked and are considerably roughened. The cocoanut oil was more active than the lard oil, but neither has affected the concrete to a greater depth than 1/32 in., and the penetration observed when the cylinders were broken was 0.2 in. in both cases. The breaking strength of the 6 by 12 in. cylinders showed only a slight decrease when compared with the strength of cylinders stored in air.

Series II and III consist of quantitative and qualitative tests on 1:⅔:1⅓ concrete tanks, in which the maximum-sized aggregate is ½ in. The tanks of Series II are under no head, while those of Series III are under a 25-ft. head of oil. The oils used in these tests were vegetable and mineral oils, the latter having gravities varying from 0.649 to 0.970; that is, from very light gasoline to a heavy residuum oil. It was found the losses were greater the lower the specific gravity; that where the specific gravity was 0.875 or higher the losses were very small. The head of oil had relatively little effect on the rate of loss.

In the tanks of Series I and II that contained boiled and raw linseed oils a very noticeable deposit of lime soap was observed. This was more marked in the case of the boiled than in that of the raw oil.

Additional experiments are being started along the same line on 1:1½:3 tanks preparatory to taking up the question of oil-proof coatings to determine their relative worth for treating concrete tanks for storing the lighter oils, for it is evident from the results obtained thus far from the tests that concrete tanks properly constructed are practically impervious to oils with gravities of 0.875 (30 B.) or heavier.

Seventy-five Per Cent Capacity of Fabricating Shops Under Contract.—The records of the Bridge Builders & Structural Society, as collected by its secretary, show that during the month of January, 1920, 75 per cent of the entire capacity of the bridge and structural shops of the country was contracted for.

How Can Laboratory Tests of Concrete Materials Be Made of Greater Value to the Field Engineer and Contractor

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Why are the results of tests and recommendations of the laboratory given so little consideration and so often disregarded by field engineers and users of concrete? That the field engineer and the contractor do not fully accept the tests and the advice of the laboratory, whether really good or bad, must be admitted by any one who is familiar with conditions in the laboratory and in the field.

Off the job, the practical user of concrete may give respectful attention to the advice from the laboratory, but on the work he is inclined to forget the procedure outlined for his guidance and return to his usual practice which he feels is satisfactory and has given him good results in the past. Beyond question, the disregard of such advice may in some cases lead to inferior work, but owing to the meager amount of testing of field concrete which is done, inferior work resulting from such a policy may never properly be impressed upon the responsible party.

Field Engineers Disregard Laboratory Tests and Conclusions.—Concreting processes have for the most part been developed through years of practice in the field, rather than by work in the laboratory, and the field engineer is disinclined to make any changes in his methods which will result in any great variation from his usual practice. Without much aid from testing laboratories, good concreting practices have been developed as a result of years of experience, and from the engineer, down to the foreman on the job there is a tendency to avoid any changes in procedure which may disarrange the old established methods, or seem to increase concreting costs.

Such an attitude on the part of the field engineer and contractor is sometimes due to expensive experiences which have resulted from the use of materials and methods which have been recommended by the laboratory. Unworkable mixtures may have been specified which resulted in bad work, delays, and increased costs, or the following out of such advice may have required changes on the job in materials or plant equipment which increased costs with no apparent improvement in the quality of the work. One or two such experiences are certain to cause laboratory advice to be shunned, and cause the engineer to fall back on well tried methods derived from experience, which he knows will furnish satisfactory results without unreasonable expense.

That such a disregard for laboratory tests and recommendations is often justified can be made clear by a consideration of the practices, and lack of practices which are employed in laboratory work. While it is not claimed by testing engineers that laboratory methods are complete and entirely satisfactory, this does not obviate the fact that the field engineer's disregard for laboratory tests and conclusions can be blamed to lack of progress in developing laboratory methods of testing, and in applying in laboratory practice a knowledge of the obstacles and adverse conditions which the latter must meet and overcome "on the job."

Lack of Agreement on Tests and Methods.—To begin with, testing laboratories are not in accord as to what methods of tests should be employed in determining the value of any given materials for use in concrete.

An inspection of reports of tests indicates the lack of agreement among different laboratories as to what tests should be made, and what methods should be employed. In planning a series of tests, consideration may be given to proportions, method and time of mixing, consistency, size and shape of test specimens as well as special tests, such as colorimetric, hardness of particles, silt, etc. There is little agreement as to whether materials should be proportioned by weight or volume, how weight per cubic foot of aggregate should be determined, what portion of the sand should be classed as silt, or how its quantity should be determined.

Often only a few of the above mentioned factors may be given consideration due either to lack of testing equipment, or lack of appreciation of their necessity. As a result, some of the essential and important features which should be determined by test may be disregarded, and erroneous and misleading conclusions may be drawn from the few test data obtained. The most essential test data, which may in some cases explain why improper conclusions have been drawn, are often omitted as of no importance, and the conclusions may be so opposed to the well established results and experience of the field engineer that he is fully justified in his refusal to be governed by the results of the test data. The wide variation in tests results which have sometimes been obtained by groups of laboratories using similar materials in a specified manner by skilled operators, furnishes additional evidence that something is lacking in laboratory practice. A few of the laboratory methods which are sometimes responsible for such a condition of affairs are worthy of more detailed consideration.

Laboratory Methods that Sometimes Are Source of Error.—Tests have repeatedly shown that the value of a sand for use in concrete cannot be determined by its use in a mortar, but that it should be employed with the same coarse aggregate which is to be used on the work. Sands which may be condemned as a result of tests in a mortar, may be satisfactory for use with a properly graded coarse aggregate. Any specifications for sands which limit the amount passing any given sieve are no doubt in many cases due to results obtained in mortar tests, and good concrete sands have been rejected because of such false conclusions based upon improper methods of test. To base judgment of a sand on tensile mortar tests is a still further step in the wrong direction and cannot be too strongly condemned. In some classes of work where a mortar is used the tension test may be proper, but the mortar test, either in tension or compression, is of little value in evaluating a sand for use in concrete.

The use of dry laboratory mixtures, unworkable under the usual field conditions, is another source of error sometimes encountered. This applies to tests of both mortars and concretes. A consistency which appears to mold well and produces good laboratory test specimens may be entirely impossible in the field, with the result that when the concrete is made on the job more water must be used to obtain a workable mix. A much weaker concrete than the laboratory tests would indicate is certain to result. It should be realized that in molding a laboratory test piece, considerable energy is expended in forming a small compact mass which is free from reinforcing steel and other obstructions, while in the field a small amount of energy is usually expended in placing a large volume of concrete which must flow in around a network of steel rods. Based on laboratory tests proportions of sand and gravel may be recommended which result in such a harsh, unworkable mixture that excessive amounts of mixing water, resulting in subsequent loss in strength, must be used for its proper placing. In case comparative tests are being made on materials from two sources of supply, the aggregate which may be judged inferior, based upon the comparatively dry laboratory consistency, may actually produce the stronger concrete in the field where a workable consistency must be used.

In laboratory tests the fact is sometimes overlooked that such a consistency as will result in maximum strength, or even approach such a value, will be entirely unworkable in the field. Some strength must be sacrificed to ease in handling and placing. Very often other properties are equally as important as compressive strength, yet most laboratory work is seemingly based upon the assumption that other properties increase proportionally with the increase in compressive strength. Experience in the field has indicated that this assumption is not true, and that concrete which must withstand water pressure, for instance, can well sacrifice strength for water tightness or impermeability.

Natural sands are often tested in comparison with standard Ottawa sand, using the quite dry consistency specified in laboratory tests of cement. Such so-called normal consistency mortars are too dry to be properly workable and should not be employed in tests of sand. The quality of mixing water is insufficient to furnish a plastic, workable consistency, with the result that unnecessary errors are introduced both in mixing and molding which would otherwise be avoided. The attempt to bring the natural sands and the standard Ottawa sand to the same consistency will be made more nearly successful in case the wetter consistency is employed.

Usuable Field Consistencies Should Be Employed in Laboratory.—In construction work it is common practice to specify that a 1:2:4 concrete shall have a strength of 2,000 lb. per square inch at 28 days, and with fairly good materials it is not difficult to obtain that strength in the laboratory, but the same mixture as used in the field has been known to have a strength 30 to 40 per cent less than obtained in the laboratory, generally due to the necessity for using a greater quantity of mixing water. Lack of specification requirement and facilities for testing field concrete are responsible for such conditions not becoming better known. On one particular job, with given materials, the specified combination of 2 parts sand with 4 parts of gravel would not result in a concrete of proper and necessary workability when the quantity of mixing water was reduced sufficiently to result in a strength of 2,000 lb. at 28 days. Here the strict adherence to the specified proportion, together with the necessity for a certain minimum consistency needed for placing under the given conditions resulted in a concrete having considerably lower strength than was predicted from the laboratory results. Such a condition on the work could have been avoided had the laboratory tests given proper consideration to the field conditions.

It cannot be too strongly emphasized that tests of sands in mortars may bear little relation to their true values when used in combination with a coarse aggregate, and that usable field consistencies should be employed in the laboratory. Such practice will almost entirely do away with the use of such consistencies as are commonly associated with the use of normal consistency Ottawa sand mortars.

One Cause of Divergence Between Laboratory Results and Field Practice.—Probably the one greatest cause for the divergence between laboratory results and field practice is the lack of some method for properly measuring and expressing the consistency, workability, or flowability of a mortar or concrete mixture. While the quantity of water used in any concrete or mortar mixture is easily determined in the laboratory when working with dry materials there is no method in common use for properly measuring the consistencies so obtained. We are familiar with the terms "dry," "plastic," "mushy," "fluid," etc., but these expressions are inexact and do not mean quite the same to any two operators, and from day to day, especially when working with aggregates varying widely in granular composition, are not used in the same way by the same operator. Although it is well understood that change in the water content causes greater change in strength than variation of any other single factor, we lack any method of test which will definitely and accurately classify any consistency so that it can be duplicated by other operators, or even by the same operator. In other words, one of the necessary and fundamental methods for the testing of concrete aggregates is lacking, and as a substitute we judge by "eye" and "feel." Throughout the test all materials may have been followed, yet the most important factor, the consistency, has merely been crudely estimated. Although we recognize that concretes must be of the same consistency to be comparable, we compare strength results obtained with materials which require wide differences in the quantity of mixing water to give the same apparent consistency.

A study of the results of comparative tests made in this manner indicates that the judgment of the operator is a very poor substitute for a method of measuring the consistency of a mixture. In a series of carefully made tests in which the consistencies were determined by the "eye" and "feel" of an experienced operator, it was later found that as much as 25 per cent more mixing water should have been used with certain of the aggregates to result in the same consistencies for the whole group. In the case of a group of mortar mixtures which the operator intended to have the same consistency, even greater discrepancies in the quantities of mixing water actually needed were found. These are not extreme or unusual cases but are representative of errors which are certain to occur in laboratory practice until some method is obtained for properly measuring consistency.

Quantity of Mixing Water and Consistency.—At present the only definite figure which has any bearing on consistency is the quantity of mixing water, usually expressed as a percentage based on the total weight of the mix, or upon the cement content alone, but such a figure is of little value in itself because of the wide variations in water requirements due to great variations in surface areas or number of particles in a unit volume of different aggregates.

The cylinder slump test has been proposed as a means of measuring and controlling the consistency. However, tests have shown that while this apparatus has some merit when working with very rich mixtures, or for controlling the consistency of the same proportions of the same aggregates, it often gives very erratic and misleading results when used with aggregates of widely varying granular composition which are met with in the laboratory. The range of water content which can be accurately measured under ideal conditions is rather narrow, and when carefully used with the same aggregate has resulted in such absurdities as a 1:2½:5 concrete being stronger than a 1:2:4 proportion.

Lack of means for accurately recording and expressing consistencies of mixture has made it difficult to make real progress in studies of concrete aggregates. Results show that the same operator cannot duplicate the same consistencies with any degree of accuracy, and the task of comparing the results obtained in two different laboratories, when working with different aggregates, is almost hopeless, since the figures for per cent of mixing water mean little under such conditions. Were it possible to assign some accurate and definite values to this most important property, the results obtained in different laboratories would be comparable after taking into account the physical properties of the cements used. Such a scheme would be of very great value to the field engineer, since the laboratory, in testing any aggregate for field use, could state the range of strength values which might be expected for different consistencies of the same proportion. Determination of the consistencies from time to time on the job would then permit of close estimates of the ultimate strengths which might be expected for that particular lot of concrete. Occasional strength tests would permit any slight adjustments to be made in the range of strength values used in case the field concrete values should differ greatly from the laboratory tests, due to curing conditions, etc.

Due to the present lack of means for measuring and controlling consistency, and the apparent failure to recognize its importance in connection with laboratory tests of concrete, the test data obtained in the many different laboratories must in most cases remain as small and isolated groups of tests, none of which bears any definite and known relation to those of another laboratory, since there is no common basis for comparison.

Consideration of the above methods and lack of methods in the laboratory can only lead to the conclusion that the field engineer and contractor are often justified in giving scanty attention to the results of laboratory tests and recommendations. There is no doubt that the causes for such a condition can be eliminated by devoting more attention in the laboratory to the conditions under which the concrete materials must be used in the field. A full appreciation of the limitations and requirements of the process of producing and placing concrete "on the job" will do much to eliminate "laboratory specifications" for concrete, which so often result in confusion and expense before their impracticability can be impressed upon the engineer who is responsible for their enforcement. The assistance which the laboratory should render to the practical user of concrete is great, and should result in bettering the quality of field concrete and the methods which are used in producing it, but such tests and recommendations which will assist in bringing about such improvements must result from the application of proper laboratory methods which take into account the conditions met with in practice.

Diatomaceous Earth as a Blend and Admixture in Portland Cement.—Tests made last year by the U. S. Bureau of Standards, using diatomaceous earth or kieselguhr as a blending material or an admixture to Portland cement show that in general the strength of concrete and mortar made with the blended cement is weaker than that made of pure Portland cement. Absorption of concrete and mortar made with blended cement has been found to be greater, according to the last annual report of the Director of the Bureau.

Comparative Tests of Applying Paint by Spraying Machines and by Hand

An interesting account of a test of methods of applying paint by spraying machines appeared in Paint, Oil and Drug Review. The information was obtained from a private source and is considered as fair and accurate as any individual statement can be. Everything possible was done to make the test thorough and indicative of the results that are to be expected from spray-making machines. The tests were made in government buildings.

The machines used at the United States Naval Hospital, Sept. 17, 1919, consisted of a 4-h.p. motor with a large air tank and a 5-gal. paint tank. The apparatus operated with a 220-volt direct current.

An experienced spray brush operator started the spray on one side of the building, and two experienced journeymen painters with 4½-in. brushes started on the other side of the building, which was an exact duplicate in shape, size and form of the side selected for the spray tests. After the cylindrical end of the building was completed, which was about one-fifth of the area of the whole building, a painter entirely unfamiliar with the use of the spray gun was shown how to operate it, and he completed the tests, including all walls and roof area. In this connection, it is apparent that a very short period of time is required to instruct a man unfamiliar with the use of the spray gun with its working. Following is a summary of the data obtained from the tests.

WALL TESTS (EXTERIOR).

Method of Application.	Area of surface, sq. ft.	Paint used, gal.	Time, 1 man, hours.	Spreading rate per gal., sq. ft	Time to coat 100 sq. ft., min
First Coat:					
Machine	4,182	6.5	9½	570	13.5
Brush	4,094	5.97	20	648	29
Second Coat:					
Machine	4,182	4.3	10½	863	15
Brush	4,094	3.9	21	992	30.7

In addition to the wall tests, data were obtained on the coating of a large area of the roof with the paint spray machine. Nearly 9,000 sq. ft. of area was coated with 22½ gal. of paint in 14 hours by one man. This included the time of mixing the paint, placing it in the containers, raising the machine to the roof, etc. It should be noted that the average journeyman painter, working on wall work, will do about 200 sq. ft. an hour and about 250 sq. ft. an hour on roof work. It will be seen from the preceding table that the journeyman painters apparently speeded up their hand brush work, as they were very much interested in the test, and they accordingly made very much higher averages than the figures just given. The results for the roof test follow:

Method of Application.	Area of surface, sq. ft.	Paint used, gal.	Time, 1 man, hours	Spreading rate per gal., sq. ft.	Time required to coat 100 sq. ft., min.
Machine	578	1.49	½	386	5.2
Brush	578	1.35	1½	428	15.5

The paint used on the work was a white lead paint, the materials for which were furnished by the Government and mixed by the men. It was tinted with ochre. The first coat weighed 17.6 lb. per gallon and the second coat, 20 lb. Both of these paints were easily handled by the spray gun. From observations, it is apparent that the spray gun will successfully handle paint of practically any weight per gallon.

On the first coat all cornices and trim were cut in with the spray gun on the side of the building where the spray gun was used. On the second coat, however, the cornices and trim were cut in with the brush to be sure of a neat job, and the time for this brush work was counted in as spray gun time.

Observation of the character of finish given by the spray versus the hand brush work on the completed first coat showed a slightly more uniform film for hand brush work. On the second coat there was no apparent difference in the appearance Both coats dried in about the same period of time, whether applied by spray or brush.

In the roof work the paint tank was hoisted to the roof and two hose leaders carried from the spray machine located on the ground. Two operators could work at the same time with the paint tank, which was fitted with two spray guns. The paint used for the roof work was a red oxide of iron paint. Only one coat was applied, which gave very good hiding power. Even in this work, which was done on the roof of the building, subjected to strong currents of air, there was apparently not very much loss of paint, the pebbled roofing showing probably less paint loss by dropping than where hand brush work was used. It was observed, however, that the overalls of the painters using the spray gun became somewhat more soiled than where hand brush work was done.

Another test was made at General Pershing's Headquarters, U. S. Land Office, on Oct. 3, 1919.

This test was conducted with a modern interior lithopone flat paint of cream color for the ceilings and light buff for the side walls of a series of rooms in the Land Office building. Both paints weighed 14 lb. per gallon. In the tests upon which data was obtained, one room was done by two painters with brushes, and two rooms were done with the spray gun by one operator. The rooms were on the second floor of the building. The machine was placed in an interior court yard, with hose leaders running up to the rooms. The following is a summary of the data obtained:

Method of application	Area of surface.	Paint used.	Time (1 man).	Spreading rate per gal.	Time required to coat 100 sq. ft.
Ceiling.					
Machine ..	660 sq. ft.	1.64 gal.	1 hr. 50 min.	402 sq. ft.	16.5 min.
Brush	250 sq. ft.	.50 gal.	2 hr. 30 min.	500 sq. ft.	60.0 min.
Walls:					
Machine ..	1,190 sq. ft	4.75 gal.	3 hr. 30 min.	408 sq. ft.	10.8 min.
Brush	750 sq ft.	1.25 gal.	2 hr. 50 min.	600 sq. ft.	22.6 min.

It will be noted from the above chart that especially good results were obtained on the ceilings with the spray brush. This method of painting seemed to be very much preferred over the ordinary method of application by hand brush. The ceilings were all arched, four arches meeting in the center of the room. The side walls had four projecting columns, one at each corner, and between the tops of these columns and the arches of the ceiling there was over a foot of school cornice. Each room also had a chimney projection and large recessed combination windows. The surface, therefore, was not of the ordinary type.

The hand brush work was marred by streaks and in places the covering was poor. The spray gun work was much better, as a heavier coat of paint could be applied.

During both the work on the naval hospital and on General Pershing's headquarters, it was found that the journeymen painters did not seem at all hostile to the use of the spray gun. In fact, after they had become accustomed to it some of them became very enthusiastic about its use, stating that they were less fatigued at night than when they used hand brushes, especially on certain types of work. It would appear, therefore, that journeymen painters, after they have had a little experience with the gun would become enthusiastic regarding its use on certain forms of their work.

Paper Mold for Concrete Test Cylinders.—A paper mold for use as the form in which to cast 6 by 12 in. concrete test cylinders was employed last year by the U. S. Bureau of Standards for use in molding samples of field concrete. The distinctive improvement in the mold is that it is slit lengthwise in order to allow nesting during shipment and that it can be assembled at the job by lacing up with a stapling machine. Each paper mold weighs only 7 ounces (one-fiftieth as much as a steel mold of the same size), and 25 of them nested for shipment occupy only about as much space as a steel mold and weigh half as much. A two-ply cardboard cylinder, such as is usually manufactured, slit lengthwise, and then dipped in paraffin, to make it waterproof, is used. This type of paper mold has been used by the Concrete Ship Section of the Emergency Fleet Corporation to obtain samples of concrete used in the concrete ships and barges built by it.

Application of Dewey System for Numbering County Bridges*

By HARRY F. HARRIS,

Engineer for Mercer County, New Jersey

It seems that for years past the counties generally have been extremely negligent in the proper maintenance of their bridges and culverts. As we well know, this has been due principally to the fact that the bridges were originally built to sustain heavy horse-drawn vehicles or an occasional steam roller and answered that purpose very well, but with the tremendous development of the motor truck for transportation purposes it at once became imperative that the counties must have exact information as to the condition of each and every bridge under their jurisdiction. Moreover, the counties were required by a recent legislative act to plainly mark each individual bridge with its capacity.

Mercer county, along with many of the other counties, was confronted with the problem of getting these data together. An up-to-date system of cataloging, indexing and compiling all the important information relative to the county bridges had never been installed.

In order to properly compile and tabulate our bridge data the first requisite is the adoption of a system of numbering. This should be as simple as possible, and at the same time it should be elastic and comprehensive.

For his own needs, the author, after devoting some study to the subject, decided to utilize the so-called "Dewey Index System," or, to be more accurate, a modification of it. The plan is so logical, simple and adaptable to so many different conditions, it was thought a few words concerning it might be helpful to some of the other counties should they desire to adopt some such system for similar work.

An elaborate explanation of the Dewey system can be found in Davies' "Engineering Office Systems and Methods." The following is quoted from that work:

Explanation of the Decimal System—The essential characteristic of the Dewey System is its method of division and subdivision. The entire field of knowledge is divided into nine chief classes, numbered by the digits from 1 to 9. Matter of too general a nature to be included in any of these classes is put into a tenth class and indicated by 0. The following are the primary classes of the Dewey System:

0. General Works
1. Philosophy
2. Religion
3. Sociology
4. Philology
5. Natural Science
6. Useful Arts
7. Fine Arts
8. Literature
9. History

Each of these classes is again divided into nine divisions, with a tenth division for general matter, and each division is separated into nine sections. The sections are again subdivided and the process may be carried as far as desired. To show clearly the working of the system the divisions of class No. 6 (useful arts) and the sections of division No. 2 of this class (engineering) are given.

600. Useful Arts (General)
610. Medicine.
620. Engineering
630. Agriculture
640. Domestic Economy
650. Communication and Commerce
660. Chemical Technology
670 Manufactures
680. Mechanic Trades
690. Building
620. Engineering (General)
621. Mechanical
622. Mining
623. Military
624. Bridge and Roof
625. Road and Railroad
626. Canal
627. River and Harbor
628. Sanitary Waterworks
629. Other Branches

It will be seen that the first digit gives the class; the second, the division; and the third, the section. Thus 625 indicates section 5 (railroad engineering) of division 2 (engineering) of class 6 (useful arts). For convenience a decimal point is inserted after the section digit. Further subdivision is indicated by digits following the decimal point. For example, 625.2 is the number indicating rolling stock; 625.23, passenger cars; 625.24, freight cars, etc

Uses and Advantages of the Decimal Classification.—The decimal classification may be used to advantage in the indexing and filing of notes and memoranda, clippings, general information, articles in technical journals, drawings, catalogues and books. For this purpose the decimal system possesses certain important advantages over the alphabetical system.

(1) It groups allied subjects. For example, suppose the alphabetical arrangement to be applied to a case of catalogues. The catalogues of the various machine tools, as planers, lathes, drills, hammers, etc., would be scattered throughout the case. With the decimal system on the other hand, all these cata-

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*From a paper presented Jan. 20 before the New Jersey County Engineers' Association logues would be grouped together under the class number 621.9.

(2) Unless an elaborate system of cross reference is used, the alphabetical scheme is ambiguous; in many cases there is doubt as to what letter should be given a subject. For example, take the item, "Automatic pneumatic block signals." This might almost equally well be indexed under A, P, B, or S. With the decimal system this item has its one number, 656.256.4.

(3) The decimal system has the advantage of flexibility and indefinite capacity for extension. For the indexing of books and catalogues only the main divisions and sections will, in general, be found necessary; but for card indexes of technical literature the most minute subdivisions must ordinarily be used.

Modification of Dewey System for County Work.—In adapting this idea to our county work it was first decided to subdivide the county into nine districts, and for convenience the townships were used for this purpose, each district or township being assigned a key number; for instance, all bridges in

Hopewell Township begin with	200
Princeton Township begin with	300
Ewing Township begin with	400
Lawrence Township begin with	500 etc.

Similarly all bridges in the City of Trenton begin with 100.

As the next step we gave to each principal stream within the county a key number, which was to follow the district key; that is, all bridges across the Assunpink Creek bear the Number 4, regardless of the township or district, likewise if a bridge was across the Millstone River it would have the number 6, and if across Stony Brook 3. In other words, these numbers all occupy the ten column. Now, should the stream be a principal tributary of the Assunpink or Millstone it would bear first, the index number of the township, next the key number for that stream and the following digit would then indicate whether it was a tributary of that stream. Should the bridge cross the principal stream itself and not be on a tributary at all, the next figure very logically becomes a cipher.

Thus we have in the first three figures the township, stream and tributary fixed. We then use a period. The next figure indicating the number of the bridge on the tributary or main stream. That is to say, the numerical arrangement of the bridge itself is taken care of at this point, the numbering commencing at the mouth of the stream or tributary.

To give a concrete example: A bridge bearing the number 541.7 shows that this bridge first, is in Lawrence Township because it is among the 500 series, next being in the 40 series places it on the Assunpink or a tributary, while the next figure shows that the structure is not bridging the Assunpink direct, but a tributary thereof, and furthermore is the first tributary in that township, counting from the mouth of the stream. Now we have arrived at the decimal point. The figure following the point shows the relative position of that bridge to all other bridges on that particular stream.

The question may arise as to how a bridge would be numbered which spans a stream forming the boundary between two townships. This very frequently occurs. We meet this situation by adding one more number in the hundreds, bearing the key number of one of the townships and separating this from the adjoining township key figure by a dash, thus 6—540.3, showing at once that this is a township line bridge, and at the same time both townships are indicated and the additional information as to stream location.

In order not to complicate the system unduly, it is well not to carry the refinements to extremes. This is particularly true if you attempt to carry the tributary numbering too far. The principal point in favor of the system, however, is the fact that the geographical location of a structure automatically fixes its number. Or conversely, if reference is made in a resolution or a report to bridge No. 740.1, as an example, you immediately are able to locate this on your index map to within a very small area without effort, while if all the bridges in the county were numbered consecutively it might take considerable time to search for its location, especially where the number of bridges might exceed 1,000.

If one desired, the first set of numbers could be omitted altogether, and as an alternative letters could be substituted for the township keys. For instance, the stream key can be prefixed by

Ho. Indicating Hopewell Township.
P. Indicating Princeton Township.
E. Indicating Ewing Township.
L. Indicating Lawrence Township.
Ha. Indicating Hamilton Township, etc.

This would eliminate the necessity of fixing the key figures in the mind for indicating the townships. This is, however, a matter of detail. Each county has its own peculiarities which have to be worked out as separate problems.

To the several advantages which have already been noted the ease with which new numbers can be inserted or interpolated might be added, also the ease with which the duplication of numbers can be avoided by reason of the fact that each series of numbers is confined to a very small area. As to the disadvantages, these seem to be few. At first sight the system may seem to be considerably complicated, but upon giving it some little study it will be seen that this is not the case. One important disadvantage which might be cited is that of numbering inter-county bridges where several adjoining counties would adopt this system. However, it would seem that by co-operation of the county engineers this could be very readily adjusted.

In this county we propose, after a survey has been completed of all the bridges in the county, to tabulate the information collected by the field corps on a card index system modeled after the system now in use by Mr. McGlave, of Bergen county. On one side of the card appears information relative to the cost of the bridge, the contractor, date when built and other pertinent data, and on the reverse side a sketch showing the type of bridge, principal dimensions of the bridge structure itself and the masonry, also the height above water level, and the present capacity of the bridge.

The Ideal Architectural Firm

An editorial in The Architect and Engineer.

To practice the profession of architecture involves practice in one or more of its three separate fields—business, engineering and art.

To exist, a firm of architects must get business. Some one must have his ear to the ground to discover who is proposing the erection of a new structure. Some one must keep tab on construction reports and visit distant cities for prospective work. Architects must enter numerous contracts, make and supervise numerous specifications, prepare estimates of cost, inspect work during construction and reject defective work, pay and receive various sums of money and keep exact records. Evidently business ability is an essential element in the firm's maintenance of existence.

If a building fails in strength or develops defects the architect is blamed. If buildings are too heavy the architect is reducing business, as owners will not build if they cannot receive a fair return on the money invested. Conveniences are required in the way of lighting, ventilating, heating and proofing against fire, the transmission of sound and vibration that require the designer to have a knowledge of chemistry, heat, light, sound, electricity, strength of materials and sound building construction. These are engineering subjects when applied to important structures.

Writing on the subject in Building Review, Mr. W. H. P. Creighton, Dean of the College of Technology, Tulare University, says:

"A really successful structure is one pleasing to the eye when viewed from the exterior or interior. While it is true that what pleases one person may not please another, artistic success must mean pleasing those most competent to judge. The artistic setting, proportions and appearance of buildings is the province of the artistic members of the firm. Simply because a young man has failed in a number of lines of endeavor does not mean, however, that he has an artistic temperament and will make a successful architect.

"An architectural firm must do enough business to support all the members of the firm. Ideally it should contain a business man, an engineer and an artist. Where there is only enough business for two, the firm is composed of an outside and an inside man. Where the firm has only one member, he must be the outside man and engineer since the securing of new business and close supervision of work during construction are essential elements to the existence of the firm. He will at the same time supervise the artistic designs. The inside work is then carried on by employes whose work is supervised from time to time. In emergencies caused by sickness or shortage, the boss must also do this work.

SCIENCE OF MANAGEMENT

Application in Civil Engineering and Construction Fields

The term Science of Management was coined by the editor of Engineering and Contracting and first used in "Cost Analysis Engineering" (1908) and explained more fully in "Cost Keeping and Management Engineering" (1909). The last named book, which contains ten laws of management and many subsidiary principles, was the first book on the science of management. In the columns of this journal many additional laws, principles and detail methods of management have been published. This section, which appears weekly, may be regarded as a serial sequel to the two books above named.

Employes' Representation as Bridge Between Manager and Worker

Of the various plans for producing industrial satisfaction which have been advanced up to the present time, the one which is attracting the greatest attention is employes' representation. In effect, the usual plan of this type creates a company or household union. At present there are about 150 employes' representation plans in operation in the United States. In a paper presented at the Eighth Annual Safety Congress of the National Safety Council, at Cleveland, last December, Mr. E. B. Tolsted, of the Independence Bureau, Philadelphia, set forth some of the generally applicable facts regarding these plans. An abstract of the paper follows:

Results Accomplished by Representation Plan.—Several years ago, Henry T. Noyes, of Rochester, stated that his own company, Art-in-Buttons, Inc., after over 10 years of periodic departmental meetings during which the company and the employes had been working earnestly for their joint good, found that approximately 90 per cent of all complaints made by the employes were justified in whole or in part. Mr. Noyes hazarded the opinion that there must be under the usual form of management a tremendous aggregate of dissatisfaction incapable of elimination chiefly because the management knew little or nothing about it. Consequently we have not been surprised to find that the existence of a works committee not only brings complaints to light before they are too serious to handle but that it eventually reduces the number and seriousness of complaints.

Almost invariably foremen have undertaken to reform their ways when their attitude of petty tyranny was the cause of grievances, and have endeavored to adjust complaints satisfactorily when first brought to their attention, rather than to allow their negligence to be the subject of discussion by committees, and thus also by the rank and file of employes, and eventually the object of a reprimand from the management. This means that complaints are more and more adjusted out of court, consequently the time of the works committee is reserved for more important matters.

While it is true that a majority of the matters are usually decided in favor of the complainant, it seems to be the feeling of most concerns that decisions are, in the main, altogether just. It should be pointed out, moreover, that in a large proportion of the cases it is immaterial to the management whether the decision is one way or the other, and it is obviously wiser to have the decision in such cases in accordance with the wishes of the employes. Many of the matters decided by the committees are such as have heretofore generally been left unsettled and allowed to become the cause of constant complaint and unrest.

Most of these plans are so worded that matters relating to discipline and discharge may be heard by shop or works committee, the same as other questions. In a few cases, the employes have been given unusually extensive authority in regard to such matters. The management of one company, for instance, granted to the employes permission to lay down the rules governing disciplinary measures. As a result, the conference board of employes' association adopted rules and penalties governing all employes. The penalties imposed are somewhat lighter than is customary in most plants where the management retains absolute authority, being principally fines or suspension, rather than discharge, but they have the effectiveness due to their representing the judgment of associates rather than superiors, and this seems to result in a reduction of the number of offenses. In other cases the employes have imposed penalties more severe than the company would have done, and the company has been forced to request a modification of the penalties.

The Filene Co-operation Association, which for many years has had authority to amend or to initiate any rule affecting the discipline or working conditions of the employes of the store, has reduced the number of offenses through its "arbitration board," which has final authority with reference to discharges. The Filene management goes as far as to permit employes to be represented by legal counsel at hearings. That this broad-gauged attitude has paid in an industrial relations sense is beyond question. The American Rolling Mill Company reports that discipline has been greatly improved as a result of the shop committee in its sheet metal and tin shop.

Many companies report that co-operation is greatly increased as a result of their works committee. The committees of the American Multigraph Co. urged the management to discharge "slackers" at a time when the entire production of the plant was essential for war purposes. The committee of the Midvale Steel & Ordnance Co. recently submitted a resolution to the management recommending that in laying off men, superintendents give preference to American citizens and in general endeavor to rid the works of radicals, Bolsheviki, and other undesirables. This resolution was passed upon favorably by the general superintendent and incorporated in an order which he sent to all of the department superintendents. The Prinz-Biederman Co. attributes to its works committee the fact that many better class workers who had left the company returned to its employ.

One very definite advantage of works committees which seems to be reported without exception is that representatives take back to the employes from the meetings a more adequate appreciation of the problems of the management, and that this, together with the increased comprehension of the executives of the problems, desires, and ambitions of their workers, results in a much better understanding on both sides.

One board of directors showed its faith in the educational value of a works committee by authorizing the employes of the plant to elect a "board of operatives" to take over the complete management of 400 houses owned by the company. A sum of money was set aside to be expended by the board of operatives on the repair and upkeep of the tenements. The company reports that while the employes have made several somewhat serious blunders in the management of the properties—such as putting a new roof on a house which should have been torn down—as a whole the education of the employes in the problems of management seems to be worth all that the company is spending on it.

One company reports that during the first few months after the establishment of its works committee system, production was increased about 20 per cent and expenses advanced less than 5 per cent, while another reports an increase of 15 per cent in production without an advance in wages. Both attribute the increased efficiency largely to the better plant spirit brought about by the works committees. The White Motor Co. claims that the works committee was responsible for considerable reduction in turnover and absenteeism. The American Multigraph Co. ascribes to its plan of representation a great reduction in the amount of tardiness. The Leeds & Northrup Co. has observed a marked decrease in the amount of time wasted by workers since the shop committee was established. The same company reports that its works committee appointed a special sub-committee of housekeeping which conducted clean-up campaigns which greatly improved conditions of the plant. The "house of representatives" of the Edmund D. David Co. established a suggestion committee and awarded prizes to employes for suggestions of improvements in machinery, methods, and designs.

Several concerns report that, while at the first election a number of "radicals" were elected, the employes soon learned to distinguish between mere talkers and competent representatives. This resulted in the election the second time of conservative persons who feel the responsibilities of representing the employes effectively and winning the confidence and respect of the management. Several company officials with whom we talked stated that the employes' representatives were frequently more inclined to be conservative than the management's representatives.

Without exception, where a works committee has been in operation for several months, the company reports that it has revealed capacity for leadership among employes which otherwise would have been suppressed or have found an outlet in some undesirable channel. William Demuth & Co. has made it a practice to regard its employes representatives as the natural group from which to select assistant foremen. Its attention was called to this possibility by the recommendation of the representatives that a certain assistant foreman be removed because of incompetency. The management, after investigation, complied with their request and appointed the chairman of the workers' committee to fill the vacancy. The Joseph & Feiss Co. reports that their works committee "has greatly developed leadership since the plan was adopted."

It has been reported that some of the best leaders developed by industrial representation have ultimately been forced out of the company by unpopularity. These men, elected by their fellows to represent them, because of their intelligence and spirit of fairness, agreed with the management too often to suit their constituents. Do not be discouraged if the representatives of the workmen disagree with the management. The men will distrust their own representatives if they agree too much with the employer. Do not educate the representatives too far ahead of the rank and file or they will be accused of being "company men."

A classification of cases which were settled during a four months' period of employes' representatives in three plants belonging to a large company is indicative of results in many other companies. Following is the classification:

Apprentice, back pay, charity, deportment, discharge, docking of pay, economy, employment, equipment, health, holidays, lighting, living conditions, machine equipment, overtime, pay methods, pay time, piece price, police, practice, promotion, quitting time, relief, rules, safety, sanitation, shifts, short pay, suspension, termination, theft, working condition, working hours, time clocks, repairs. The total number of cases for this period was 154 for the three plants, of which 132 were settled in the affirmative, that is, in accordance with the request as orginally presented to the committee.

Our study reveals the fact that while minor matters of complaint involving personal discrimination are likely to be the first matters brought before the committee, it is not long before the committee is required to consider broader questions involving a discussion of shop practices, efficiency, discipline, and company policies. Industrial representation has tended, I believe, to make lighter the task of management by reducing the causes of friction between employers and employes, and by arousing the workers a constructive interest in the progress of the industry in which they are engaged.

How to Install a Representation Plans.—Industrial representation is in successful operátion in plants varying widely as to process and products, size and complexity of organization, and as to the character of the working force. None of these factors seems to determine the success, although each of them affects it and must be taken into consideration in working out the application of any plan to particular needs. But there are a few suggestions which I think it would be well for every one to consider when contemplating a plan:

Install it under peaceful conditions. One large company inaugurated a plan as the result of a strike, and the plan ended in another strike some time later. The company is now attempting to make a new start. To propose a plan to men on the verge of a strike is also almost certain to result in failure to win over the men.

To attain its highest success, a plan should be developed gradually, each step in so far as possible resulting from suggestions or requests of employes. By all means, do not impose a ready-made plan; let the men help work it out; it will be a better plan and they will feel that it is their own. Remember that attitude of our forebears toward English-made laws applied to the colonies. And no matter how good the plan seems to be, actual use will show need for changes.

See that the plan is simple in form so that procedure under it is easy to understand and to carry out. As to the specific form, we find that the best results have been obtained with the joint-committee. But give opportunity for free discussion, that is, discussion without the presence of the management. It has been found good practice to alternate joint and separate meetings, with final action taken only in joint meetings. At a banquet held recently by the Standard Oil Company of New Jersey for the representatives of the men and the management, one of the employes' representatives suggested the establishment of separate boards for the management and the men. This action was not especially desired by the representatives, who had already taken up the subject once and voted against separate boards, but the men felt that their delegates would not speak freely before their "bosses."

In some plans the committees deal only with working conditions and welfare work, such as light, ventilation, locker rooms, etc.; in some they deal with all matters which directly concern the worker, including wages and hours. There are drawbacks to both plans. On the one hand, committees which have been restricted in their activities have grown restless and felt that they were deprived of their just rights. On the other hand, committees which have been given free sway have sometimes failed to use judgment in the determination of hours and wages. In one plant, it is said that wages were forced up, despite the company's cláim that they could not meet an increase. The reply of the men was, "Raise the price of your product." Experience would seem to show that a middle course works best. Give your committee supervision over working conditions and welfare work; educate them through the use of this function to a better understanding of the position and problems of the management; then as they show themselves capable of handling the more serious problems, extend their authority toward grievances, hours, wages, absence, cost of living, community conditions, etc. In most cases, it will be found that the desire for a wider scope of activities will go hand in hand with the growth of ability to handle the bigger subjects.

We advise that every employe, man or woman, citizen or alien, be made to feel as far as possible that he has a part in the operation of the plan. In one plant, voting was restricted to citizens, but all were, of course, allowed to present grievances. A group of foreigners did not understand this point, and struck because they thought they had no means of presenting their grievance. After the plan has been formulated be sure that every employe knows what it means and who made it. The man first consulted will advise as to the best method to be followed. Use the plant organ again and again to supplement word-of-mouth publicity. Do not hurry at this, or, indeed, at any point. Frequently the management fatuously prides itself on its excellent plan, when the men know nothing about it. In a plant which we visited several months after the installation of a representation plan, almost half the men who could not speak English did not know of its existence.

It is especially important to make it plain that the plan in no way interferes with membership in unions or with existing relations of the management with labor unions.

Keep adequate records of all meetings and make them accessible to all. The main decisions should be posted on bulletin boards in each department and published in the plant organ.

Usually best results follow holding meetings during working hours. In one case, which has come to our attention, the representatives requested that the conferences be held out of hours, as they would feel less constraint in voting as they pleased. As a rule, however, committees which meet outside hours have failed to hold the interest of the representatives.

This lack of interest is one of the foes of employes' representation.

Study, Co-Operation, Dividends and Success

To the editor of Engineering & Contracting, who has so ardently urged the importance of systematic study by engineers other expressions of a similar opinion with reasons therefor are obviously welcome. Such opinions and reasons are given by Mr. Russell Waldo in an article entitled "The Successful Employment Department," published in a past number of "Industrial Management." The fact that the discussion does not relate to engineering or to any other class in particular, makes it the more significant. Also it is to be noted that Mr. Waldo points out that the benefits of study accrue jointly to employe and employer. He says:

"The principal drawback of the new and more efficient idea usually rests with the man who has the authority to put it into use. He does not grasp the idea, does not know the greater benefit to be derived from it, has heard no one discuss it and has been unable to read upon the subject so as to understand it. It is surprising how many such men who do not know are unwilling to be caught learning the actual working principles of the modern methods. Some are almost ashamed if they are detected educating themselves. The man who makes the best department head regardless of his position is the one who is always open to argument, is always ready to consider and learn the actual workings of a new idea, who has the advancement of every man under him continually before him, and who tries to promote or make the way easier for each of them."

A Few Important Fundamentals.—In selecting the employe the interviewer strives to pick the man who studies and profits by what he sees. All progressive organizations are beginning to realize the value of study in measuring a man's future value. What effort of a man will win for him greater respect from a firm than study? Study is the very foundation of success. No man ever succeeded who did not study in some form or another. The progressive employment department is placing more stress upon this element now than ever before. This is because the eager strife for supremacy in the commercial world today is gathering every man who holds out any determination to study.

"Unbelievable Dividends" Upon the Cost of Education.—Many corporations are finding it profitable to establish schools in which they instruct their employes. This pays unbelievable dividends upon the cost. It was the progressive employment department that first found the need of the school and, since the first one was established many years ago, every firm as it rises now is establishing schools. Many have been established within the last few months upon the success that has been gained from others.

The best employe is the one who enjoys studying. I do not mean by this the one who studies in a haphazard method. He should lay out or have laid out for him a definite plan of study. This he should follow to the letter.

The greatest incentive for study is always offered in the subject in which the student is interested. This often is not the field which he is working in, although he enjoys preparing himself for the thing that he intends to follow. This is usually reaction from the work which he follows during the day. A young man studying in a field different from his work looks forward to his evening hours when he might relax his mind to his favorite study. The progressive employment department today is encouraging every man to study something and eagerly searches among men who prepare themselves for something demanding greater responsibility.

Value of Contentment.—A man to succeed must be contented in his work. This element is controlled by love of work, environment and sufficient remuneration from his labor to allow for the necessities of life. The bearing which these elements have had upon his life in the past should be carefully considered. The future can and should be favorably controlled.

Contentment has much to do with co-operation. Without contentment there can be no co-operation in any corporation.

Co-operation in any industry is the prerequisite of its success.

Co-operation cannot be had from the average man until he has been assured some sort of compensation for his endeavors. Very few in the production department realize that the greater their productive value to the firm the greater their

A New Conception of the Relation of an Architect to His Draftsmen*

By GEORGE BAIN CUMMINGS

There was held recently in New York a limited architectural competition. The proposed building was to be of considerable size and importance; the remuneration and prestige offered to the successful competitor were quite well worth his best effort. Coming during such an unsettled period as the present with so little new work finding its way into the offices of architects, such a commission as awaited the winner of this competition would be most welcome. There was every reason, therefore, why the competition was worth winning and, consequently, worth trying hard for.

The winning solution was a distinguished design. The most careful study was evident in the elevation, the most thoughtful consideration in the plan. It was apparent that every aspect of the problem had received scrupulous attention, and every feature of the solution evidenced deliberately weighed judgment.

The solution which seemed generally to be rated second fell measurably below the standard of the winner. A confident handling of the problem, which only the most thoughtful study and critical analysis could impart, was lacking. There was not the sure mastery of the problem that the winning solution revealed.

Shortly after the judgment and exhibition of this competition, I learned, from draftsmen employed in the offices of the architects producing respectively the two solutions discussed above, the manner in which the solution had been arrived at in each case. The comparison is of more than passing interest.

In the office in which the winning design was produced, the program was placed before the whole organization. It was studied and discussed by all, from the principles to the most junior draftsman. From this action—that of a committee of the whole—the scheme was arrived at. The various members of the force took up this scheme and worked out its details. Nothing was accepted or decided until it had been presented to the rest and subjected to their analysis, criticism, and suggestion. This was a collaborative effort in which everyone in the organization bore as large a share as he was able to assume. The result was a collaborative solution, which might be expected to survive critical analysis, inasmuch as it had been produced by such an analysis on the part, not of one, but of several, trained persons.

In the other office, a different and more usual procedure had been followed. The principal and two or three others studied the program and determined the scheme. They made the initial sketches and determined the essential elements of the design and then turned the scheme into the drafting-room to be drawn up and presented. Those who worked on it had no control over the design, no opportunity to criticize or discuss it with the few who had determined it. Some of them felt that fundamental mistakes were being made in this solution of the problem, but there was no appeal. This condition chilled the enthusiasm of the organization and made the members silent, if not openly hostile, toward the solution.

The first office produced a winning solution, the other a losing solution. I am not attempting to prove cause and effect in this instance, although I believe that would be easy. I am simply presenting facts. Furthermore, let me say that I do not insist that in such a procedure as that described do we find an infallible recipe for winning a competition. As a matter of fact, you and I are not particularly interested in the familiar type of competition. What I would have you read from the title of these notes is, that there is a big Idea, in the working out of which an architect may achieve Success. The essence of that Idea is a new conception of the relation of an architect to his draftsmen.

Your draftsmen are of two general kinds—live and dead. The dead ones are simply draftsmen—never to be more or otherwise. They are worth very little to you. They work for you by the hour at an established gait. They have no enthusiasm for the work, for your success, for their own futures.

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*From the Journal of the American Institute of Architects.

They may be round pegs in square holes, or they may be handicapped by lack of education and contact with fine things. In either or any event such a man is a poor investment for you, and is making a poor investment of himself. Study his case, urge him to get into a line of work for which he will have some enthusiasm, help him make the right connection, or strike some spark to quicken his dying soul and arouse ambition and enthusiasm in him toward the work in hand. Briefly, fire him, or fire him, but don't exploit him. Don't shake your head over him and say, "Poor fellow, he'll never be anything but a draftsman," and then continue to pay him starvation wages and reflect comfortably that if his work is not brilliant it is at least steady, and surely is cheap enough.

Of course, the majority of your draftsmen are the other kind—live ones. They are really not draftsmen at all, but architects in the making. The difference between them and you is simply one of degrees in proficiency and experience. (And sometimes the balance tips to their side!) Every once in a while one of your best men drops into your office to say that he has landed that big job or entered into a favorable partnership arrangement. And so he is added to the list of practising architects. And you select another man to move up into the position he has vacated, and that means you have to hire another junior draftsman or a young college graduate, or promote the office boy and hire another youngster. And so they pass up through your organization. You take them in at the bottom raw and green, but eager and teachable; you graduate them finally, and compile a list of the firms you have fathered and trained. And one day your last call comes, or you retire from active work to grow old leisurely, and your head men step into your shoes and carry on the practice. Don't you see that with these live draftsmen, as it was with you, it is a progression, and that from the time the young man decides that if he is to find his immortal soul he must be an architect, he must be rated and reckoned with as an architect in the making? Are any of us in danger of ceasing to be "in the making"? May an architect cease to learn and develop, with impunity?

And so these live draftsmen of yours, these potential architects, are your professional brothers just as much as are your fellow Institute members. Your welfare and theirs are coincident. They are your brain and muscle, your strength and genius, if you will but let them be, if you will but acknowledge them. How senseless not to make the most of your investment in them; how foolish not to utilize their talent, their youthful imagination, their spiritual fire! The architect who won the competition was wise, for he did so utilize those priceless qualities.

The unrest sweeping and rocking the world is gripping these draftsmen. We hear of unions of them forming or contemplated. They would not be in such movements if the architects generally had pursued an enlightened policy toward their employes. Even now they look to other fields of work, preferring another career to the alternatives of standardized labor or allegiance to a tottering—is that too strong a word?—at least floundering, profession.

Whether you have a competition on the boards or only a job, or six of them, sort your draftsmen into the dead and live classes, get rid of your dead ones or transform them into live ones, and then sit down at the same table with them all, and talk and think and create together. Collaborate—not because it may be the way to win a competition, but because it is the only way in which the true architectural traditions can be carried forward—and things that do not go forward go backward. Nothing stands still.

Result of an "Intelligence Test" of a Civil Engineer.—Frank Crane, in the January, 1920, issue of The American Magazine, gave a series of questions which he said every intelligent person should be able to answer. The wife of a certain civil engineer tried them on her husband with the following result. Does this throw any light on why engineers are not rated higher?

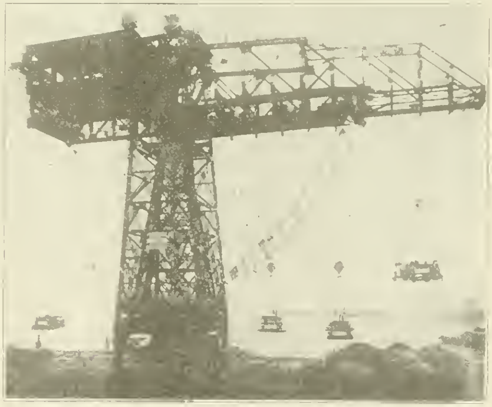
	Per cent.		Per cent.
Bible	100	Politics	95
History	95	Science	80
Places	100	Scientific Terms	90
Books	90	Business	95
Fiction	85	Theater	90
Art	35	People	90
Music	60	Miscellaneous	89
War	95		

New 500-Ton Capacity Crane at Philadelphia Navy Yard

The largest crane of its type in America, with a lifting capacity of more than 1,000,000 lb., has been completed and put in operation at the Navy Yard, Philadelphia. The crane is located on the recently constructed 1,000-ft. fitting-out pier at the yard, and its completion represent a definite step in engineering progress. It will serve the purpose of placing the heavier parts, such as the turrets, ordnance, armor plate, boilers, machinery, etc., on the capital ships to be constructed at the yard as well as that of removing and placing heavy parts in connection with repairs to ships.

An idea of its size may be had from the fact that a 10-story building could be placed under the jib of the crane and that its overall height is over 245 ft. or about that of a 17 or 18-story building. The cost of the entire crane structure above the foundations was approximately $875,000 and of the foundations $120,000.

Tests of the new crane, in the course of which it was to 125 per cent of rated capacity and operated in all cycles of duty, have recently been concluded. The largest single load in these tests was 980,000 lb. In the most spectacular of these tests the crane lifted a total load of 1,010,000 lb.—a locomotive weighing 100,000 lb. on the auxiliary (50-ton) hoist, a load of steel billets weighing 416,000 lb. on each of the main (175 gross ton) hoists and locomotive weighing 78,000 lb. on the machinery house crane.



Crane at Philadelphia Navy Yard Lifting Total Load of 1,010,000 Lb.

The maximum capacities, 50 gross tons for the auxiliary hoist and 350 gross tons for the main hoist, were determined in conjunction with the Bureaus of Construction and Repair and Steam Engineering as ones that would permit turrets, guns, etc., to be completely assembled (except for armor plating) in shops, and transferred to the ships on barges or cars and placed aboard the ship intact—eliminating the operations of dismantling and subsequently reassembling on board ship usually necessary, with a consequent marked increase in economy of time and money in the construction of capital ships. The large weight-handling capacity will also make the crane of inestimable value in the performance of major repairs to vessels.

The location of the crane at the waists of the ships berthed either side of the pier will permit the placing of most of the heavy weights without moving or turning the ships. The placing of minor parts, which will form the greater proportion of the work of fitting out a ship, will be rapidly and economically done by two auxiliary, small capacity (5 to 10 tons), quick acting, cranes of the same general type, but with a traveling instead of a fixed tower, and smaller height and reach, which will be installed to operate along the pier on each side of the main crane. In some cases it is contemplated that these cranes may also be supplemented by floating derricks where it is desirable to expedite the construction by placing medium weights beyond the reach of the pier cranes without moving tne ship.

General Description of Crane. The crane, as designed and constructed, consists of a fixed portal 6 ft. square, supporting, on deep girders, an octagonal tower about 56 ft. wide at the bottom and tapering to a bearing pintle, 5 ft. in diameter, at a height of approximately 201 ft. above the deck of the pier. Supported vertically on this bearing pintle and revolving thereon is a horizontal cantilever jib or boom 300 ft. long over all, to which is rigidly attached a "petticoat" which envelopes the fixed tower from the bottom of the jib down to a height just above the portal. The entire vertical load is transmitted to the tower at the pintle, mentioned above, but lateral thrusts are taken into the fixed tower at the pintle and into the circular girder at the base of the octagonal tower by the circular girder which forms the rim of the "petticoat." The forward cantilever of the jib contains the three runways for the trolleys that carry the loads. The rear cantilever of the jib carries the counterweight and the house containing the machinery and drums for hoisting and lowering loads and racking the trolleys in and out on the forward cantilever. The machinery for revolving the jib is located at the level of the top of the portal girder and the rotating impulse is transmitted through the rim of the "petticoat."

This enveloping "petticoat" provided a greater than usual factor of safety against failure by overturning of the jib, in the event of excessive accidental overload of crane, than would be given by the other and more usual design, under consideration by the Bureau, in which the jib is simply supported by the tower on a circular bearing similar to that of a swing bridge or a turntable. The entire framework of the crane is of structural steel of bridge grade and the entire operation is by means of electricity.

Access to the machinery house, etc., is provided by means of a steel stairway in the tower, an electrical elevator mounted on the outside of the "petticoat" and the jib.

Details.—The forged steel hooks by which the loads are raised have, in the case of the 175-ton hook, a shank 9 in. in diameter, and in the case of the 350-ton hook, a shank 13 in. in diameter. The 50-ton block and load are carried by eight 1⅝ in. wire ropes; the 175-ton block and load by 16 1⅝ in. wire ropes running on 50 in. pulleys and the 350-ton block and load by 32 1⅝ in. wire ropes. The 350-ton block is carried from the two 175-ton blocks by a steel equalizing beam 4 ft. 10½ in. deep.

The clear lift of the main hook is 111 ft. above and 29 ft. below the deck of the pier, and of the auxiliary hoist; 151 ft. above and 29 ft below. The three trolleys carrying loads in and out on the forward cantilever of the jib operate on separate runways—the one 50-ton trolley to a distance of 190 ft. from the center of the tower and the two 175-ton trolleys to a distance of 115 ft. from the center of the tower. The two 175-ton trolleys are arranged so that they can be coupled together in order to lift, by means of the additional hook and equalizing beam above mentioned, the capacity load of the main hoist, 350 gross tons or 392 short tons.

The forward cantilever is 200 ft. long, 40 ft. wide from the tower to the limit of travel of the main hoists and 13 ft. 4 in. beyond that. Its trusses have a depth of 40 ft. at the tower.

The rear trusses, carrying the machinery house and the counterweight, are 100 ft. long and 20 ft. deep and form a cantilever 40 ft. wide.

The machinery house itself is a large building 80 ft. long, 43 ft. wide and 32 ft. high and contains the machinery for hoisting and lowering the hooks and for racking the trolleys. The two main hoisting motors and the one auxiliary hoisting engine are of 87 h.p. each; the two main racking motors and the one auxiliary racking motor are 27½ h.p. each. The drums on which the ropes for the main hoist are wound are 10 ft. in diameter and 14 ft. long and revolve on a drum shaft 10½ in. in diameter.

The machinery house also carries an overhead traveling crane of the bridge type of 35 tons capacity (determined by the weight of the main drum and drum shaft) for the handling of machinery. The runway on which this crane operates extends through the rear wall of the machinery house a distance of 17 ft. By lowering the rear wall of the house, which is especially designed for the purpose, the crane is permitted to travel out beyond the end of the building in order to transfer parts to and from the pier, about 215 ft. below.

The counterweight is of concrete and weights 628,000 lb.

The pintle supporting the rotating part of the structure (the jib and "petticoat") is of cast steel, 60½ in. in diameter, and when the crane is loaded to rated capacity, carries a vertical load of 5,834,000 lb. and takes a lateral thrust due to maximum conditions of wind, loading and eccentricity of 607,000 lb. The vertical load is taken by means of 220 roller bearings 3 in. in diameter and the horizontal thrust by 62 rollers 2 in. in diameter. The metal of the bearing rollers is a high carbon, high chromium tool steel with the exceptional ultimate bearing strength of 290,000 lb. per square inch after hardening treatment (raised from 96,000 lb. per square inch before treatment).

The eccentricity mentioned is due to the fact that the jib is designed so that the overturning moment, or tendency of the jib to overturn, is equal and opposite in direction under each of the two conditions of no loading and maximum rated load; in case of no load on crane the center of gravity of the rotating mass is 12.45 ft. behind that of the tower, and in the case of maximum load 10.65 ft. in front of that of the tower. This tendency toward overturning is resisted by the horizontal bearing of the bottom rim of the "petticoat" on the circular girder encircling the tower legs, as well as by the horizontal bearing at the pintle, and, in the case of that due to vertical loads, is neutarlized at the top of the portal girder. The horizontal thrust at the bottom rim of the "petticoat" is taken up by means of sixty-four 26-in. wheels mounted on two chains and bearing on a circular girder 55 in. deep and 64 ft. in diameter.

The sluing or revolving mechanism located at the top of portal consists of a 87 h.p. motor with gearing, driving 4 pinions working into a rack 64 ft. in diameter, having 768 teeth of 3.1416 in. pitch and 12 in. face.

The operating speeds of the crane are as follows:

Hoisting—
    Main hoist, 2½ ft. per minute.
    Auxiliary hoist, 15 ft. per minute.
Racking—
    Main trolley, 15 ft. per minute.
    Auxiliary trolley, 80 ft. per minute.
Revolving—(One complete revolution in 12 minutes.)

All of the operations of the crane are controlled from an operator's cab located under the jib adjacent to the tower and in full view of all of the handling operations of the crane. The machinery is controlled from the cab by means of master controllers operating solenoid switches located in the machinery house. Clutches for throwing the hoists into high or low gear and for coupling together the main hoists when using the equalizer beam, are located in the machinery house and are mechanically operated by levers in the operator's cab.

The structure is designed so that, when it becomes necessary to renew pintle bearings or make repairs, the entire rotating structure (the jib and "petticoat") can be jacked up from the portal by means of four 30 in. jacks of 560 tons capacity each.

The portal has four legs, spaced 56 ft. center to center, each of a sectional area of 385 sq. in. of structural steel, supporting the massive girders 9 ft. deep which carry the octagonal tower. The maximum load on one of these legs was computed at 3,000,000 lb. under maximum conditions of wind pressure and for this load the legs and the foundations were designed. The portal has a clear height of 25 ft., 7 in., which provides ample clearance for locomotive cranes or other equipment on the two tracks passing through it. A power substation which furnishes the electrical current for the operation of the crane is also located beneath the portal.

The entire dead weight of the crane structure is calculated at 4,000 tons. An uplift of 59,000 lb. is possible in any one leg due to maximum wind loads on structure, four bolts 3 in. in diameter are used to anchor each leg to the foundations.

Foundations. Each of the four tower legs are supported on grillages, 10 ft., 4 in. square, made up of two layers of rolled steel girders embedded in massive reinforced concrete caps, 35 ft. 4 in. square and 9 ft. 6 in. deep, tied securely together longitudinally and transversely by the deep reinforced concrete girders of the pier deck. Each of these caps rests on 156 timber piles driven to the hard cemented gravel river bottom and cut off at water level. These piles are supported laterally by an earthfill inclosed and retained by reinforced concrete sheet piles jetted and driven into the hard river bottom. Most of these sheet piles are 18 in. by 24 in. in section and 52 ft. long, weigh about 12 tons, are tongued and grooved to interlock one with another to form a reinforced concrete wall around the entire foundation 24 in. thick and spanning from caps, and lateral connecting girders to river bottom.

The crane structure was designed by the McMyler-Interstate Co. of Bedford, O., under the general supervision and in accordance with the specifications of the Bureau of Yards and Docks and was erected by that company under the supervision of the public works officer at the Navy Yard. The contract for the crane was awarded to the McMyler-Interstate Co., in January, 1918, and the erection was begun at site in April, 1919, and complete in December, 1919.

The foundations were designed by the Bureau of Yards and Docks and constructed by the Snare & Triest Co. of New York City as a part of the 1,000 ft. by 100 ft. fitting-out pier. This construction was also under the general supervision of the public works officer of the Navy Yard.

Suggestions for Inspection of Timber Bridges

It is difficult to distinguish between a safe and an unsafe condition in a wooden structure. What might be permissible under one set of circumstances might be positively dangerous under other conditions. On a steel bridge the inspector looks for wear or loosening of joints, indications of fractures and the extent of corrosion, all of which are usually surface manifestations. Even though the rust may be very thick, if it is scraped off the sound metal is exposed beneath and the amount of this still remaining may be readily measured. In the case of a timber structure, on the other hand, the question is one of possible defects throughout the body of the wood. While the actual decay may be apparent from the outside, this is not always the case, and especially in old structures there occurs a reduction in the strength of the material through a slow deterioration of the wood substance. This condition must be judged by any evidences that the wood is becoming soft or dosey and by indications of weakening, such as crushing of the fibers when subjected to cross grain compression.

Thus it is seen that the problem of determining whether a wooden structure may be carried over or must be renewed is far from simple and the man charged with this work should receive the benefit of all the data available on the subject. Useful observations on this important matter, based on information obtained from A. F. Robinson, Bridge Engineer, Atchison, Topeka & Santa Fe System, Chicago, Ill., are given in the Railway Maintenance Engineer, from which the matter in this article is taken.

Bridge Ties.—Ordinarily ties are removed because of mechanical wear rather than rot. The ordinary cause for removal is rail cutting aided by "spike killing" and sun checking. Douglas fir ties have been known to separate into layers along the annual rings, giving the effect of unrolling like an onion. The ties do not last as long as the other parts of a bridge. For instance, on one 400-ft. trestle only 10 per cent of the original ties were in place after 12 years. In deciding whether or not the ties must be renewed, the criterion is that they must have sufficient strength to prevent serious breaking or bunching in case of a derailment.

Stringers.—It is especially difficult to say just when a pine stringer is unsafe or should be taken out of service. In more than 20 years of service on one road, few cases were noted where the stringers were actually rotting and getting soft. In these cases the timber was soft on top for 1¼ in. of the depth, and when removed the stringers were found to be getting very dosey and weak. They were not taken out a minute too soon.

In general, stringers are replaced because they are evidencing a loss of strength through excessive age; nevertheless age is no criterion for renewal. Bridges have been rebuilt where the stringers were only 10 or 12 years old, and investigation showed that it would not have been safe to reuse very many of them. On the other hand, there are stringers with 16 to 18 years of service that have commenced to show signs of decay or excessive deflection.

When stringers lose their strength they begin to break, and this is about the most conclusive evidence that they need to be renewed, it being assumed, of course, that there are enough stringers in the panel to keep the stress within reasonable limits for the train loading carried. Fortunately experience demonstrates that only one stringer of a chord will break at a time, so there will be plenty of warning before another one in the same span is broken. An engineman can readily tell when his engine breaks a stringer as he rides over the bridge. The deflection of the stringers should also be noted, but as long as this is not sufficient to make uncomfortable riding, the stringers need not be removed unless the breakage is excessive.

The conditions outlined above will suffice in most cases for bridges subjected to climatic conditions similar to those along the lines of the Santa Fe. There are, of course, circumstances under which decay may be a much more important consideration. Under such circumstances rotting or excessive softening of the wood must be carefully watched. The sticks should be prodded with a brad-awl or a knife and examined for a tendency to crush down over the cap. When the packing of the stringers in the chord is such that the sticks are in close contact for all or a part of their length considerable decay may take place which is not apparent from external observation or from the action of the span under load. Such conditions must be watched carefully.

Caps.—Where piles are properly spaced, bents with broken caps can frequently be run for some time by installing what would be called minor repairs. These would consist of an extra sub-cap on top of the old one or of pieces spiked to the side of the cap. As a general rule it is safe to take a good many more chances with caps than with stringers or ties. If the cap is not splitting or crushing badly it can be used until it actually begins to break down or until the timber begins to rot.

Piles.—When the piling is properly spaced and thoroughly driven it can be run with safety until there is less than 4 in. diameter of good timber at the ground line for hardwood and about 6 in. for soft wood piles. This rule is also subject to variations with climatic conditions. While 5 or 6 in. of good timber would justify carrying over a pile in northern territory where decay is relatively slow, it would be necessary to have from 8 to 10 in. of sound wood in a pile subjected to a warmer and more humid climate where decay is more rapid.

The piles in a bent do not all wear equally well. Frequently one or two piles in a bent will fail some years before the others are worn out. When this occurs a cripple is inserted, the pile is cut off below the point of rot and a post put in on top of it, or the decayed portion is cut out and a short block is inserted with enough scabs to splice it thoroughly to the parts above and below. In doing this it is necessary that the bent is adequately sway-braced.

Frame Bents.—As a general proposition the posts and sills in frame bents can be run until the timber actually begins to crush down, this without much reference to the age. Of course, when the timber gets soft so that one can poke a brad-awl or penknife blade full length into it, it is time to have it removed. In many cases the sills will rot or fail a long time before the posts do. In cases of this kind a second-hand sill can be installed. These sills however, like the caps, seldom break in service and do not need to be replaced until the timber starts to crush down badly under the posts.

Wooden Truss Bridges.—Wooden truss bridges must be watched more closely than trestles because of the more serious consequences attending the failure of any main member under load. Like bridge stringers, the members of a Howe truss deteriorate through weakening of the wood rather than from decay, and under proper care may last many years. The task in inspecting one of these structures is to look for evidences of weakening. The members should be prodded with an awl or even bored with a small auger to note if the interior wood is still hard and bright. It is also necessary to note any tendency of the chords to crush across grain under the angle blocks or at the end bearings, or for the fibers at the ends of the posts to broom. The tension chord splices should be examined to see if the abutting ends of the chords are pulling apart through weakening of the timbers in the splice. If the camber is continually coming out of the span it is a sign of weakening of the timbers. Pile piers under a truss span should be considered the same as the bents in a trestle, making due allowance for the greater loads they carry.

Thorough and Frequent Inspections Necessary.—To pass upon the condition of a bridge in the light of considerations such as those referred to above it is necessary that the structure be inspected thoroughly and at frequent intervals by somone competent to assume the implied responsibility. Regular inspections should be made at intervals of not over three months by a division bridge inspector, whose duty it is to find out what condition the bridges are in and report any objectionable condition as soon as he discovers it, rather than to determine what should be done.

At least once each year an official inspection should be made by officers of the engineering or maintenance of way departments concerned with the care of bridges. Inspection of individual bridges may be required at more frequent intervals and should be made whenever necessary. The party should include the district or division engineer, the master carpenter and if possible the bridge engineer. Those making the inspection should not be concerned at the time with matters foreign to bridge work, and the time allowed for the trip should be adequate for detailed, painstaking examinations. A stenographer should be present to take full notes on the observations so that complete detailed information will be available for a careful study of the structure.

Relation of Engineer to Architect*

By FRANCIS C. SHENEHON.

In order to review in my own mind our reasons for the inclusion of architects in our bill—and to keep these reasons active in your mind—I am discussing at some length the situation which confronted us and the avenues which our minds traversed in reaching our conclusion.

Historically we find the builders of fortifications, the military engineer, and the builder of dwellings and temples, the architect, were earliest on the ground. The distinction was then between soldier and architect, not between engineer and architect. All of us who have translated his works, remember that Julius Caesar built a bridge—and we know of the military Roman roads of England. In his illuminating lecture on "The Romance of Engineering," Professor C. J. Tilden, of Yale, shows that Vitruvius in his treatise, written about the beginning of the Christian era, "divides the field of architecture into three main divisions as follows:

1. The art of building.

a. The construction of fortified towns and of works for general use in public places—

I. For defensive purposes—the planning of walls, towers and gates, permanent devices for resistance against hostile attacks.

II. For religious purposes the erection of fanes and temples to the immortal gods.

III. For utilitarian purposes the provision of meeting places for public use, such as harbors, markets, colonnades, baths, theaters, promenades, and all similar arrangements.

b. The putting up of structures for private individuals.

2. The making of time-pieces. (Sundials, water clocks, etc.)

3. The construction of machinery—

a. Civil water wheels, screw pumps, hodometers, etc.

b. Military—balistae, catapults, rams, siege machines, etc.

The very considerable Avignon bridge across the Rhone river (about 1200 A. D.), with 18 clear arch spans of from 65 to 80 ft. each, in a swift-flowing river subject to ice jams, was regarded as a work of architecture. The term architect of bridges is authentic. Michael Angelo (1475-1564) was not only the architect of St. Peters, but he designed the fortifications of Rome.

Leonardo da Vinci (1452-1519) not only made plans for the Milan Cathedral, and painted the "Last Supper" and "Mona Lisa," but he was a chief military engineer, and a hydraulic engineer dealing with irrigation, river control and harbor works, and designed a flight of six vessel-locks. The utilization of his creative imagination in directing the forces of nature appears to have appealed to him no less strongly, than in architecture, sculpture and painting. He styled himself engineer as well as architect.

The term architect in its etymology means "master builder." Should the determination of the field of architecture rest on a historical basis, its scope would be far wider than latter-day engineers would wish to concede. The wonder is not the present encroachment of architects upon the legitimate field of engineering, but the expanse of the fields once interchangeable over which engineers have gained sole dominion.

It is not material to put one's finger on the year when a distinct cleavage was visible between architecture and engineering, because the two are so closely knit now that it will require a surgical operation to separate them. It appears that in the evolution of construction, two classes of builders, blood-brothers in fact, have by some vagary of word-growth been verbally torn apart and their kinship sometimes questioned. It is odd that in this juggling of old terms and the emergence of new terms, one class of engineers—and a class whose work is of the highly-specialized, technical kind which deals with the direction of great mechanical forces—has kept the old family name, the naval architects.

What I am endeavoring to accent is that an accident of name-evolution has tended to segregate one class of master-builders, from the other classes of master-builders, and that this segregation does not grow out of any vital difference in fact. It may be thought that initiative and imagination are the qualities of architects, while engineers deal with the prose of construction. Analysis will however reveal the fact that 80 per cent of the architectural structures of our cities are commonplace, with no peculiar beauty or originality. Now and again a Woolworth building springs sky-ward, worthy of the phrase "frozen music," and we recognize again the master-builder of the sixteenth century. But the same quality of mind went into the wireless telegraph, the airplane, the Panama canal and hydro-electric developments and transmission at Niagara. Engineers without creative imagination are as mediocre as architects without the same vital and indispensable attribute of the master-builder. Architects must recognize that scientific imagination is on the same high plane as their own best creative thought; and engineers must concede the esthetic contribution of architects in adding to the durable satisfactions of life. Both are creative workers.

An architect is an engineer whose higher activities are those of an artist; and the two kinds of activity are blended in an individual man; in some cases the architect is 99.44 per cent engineer, and sometimes he is 99.44 per cent artist; and in some cases the blend is fifty-fifty. As the activities of architects reach out from the nucleus of fundamental builder into fields of art, so the activities of engineers, all centered on this same nucleus, reach into individualized fields. The mining engineer is much geologist and chemist; the sanitary engineer reaches toward the biological sciences and medicine; valuation engineers are part economists; the mechanical engineer touches industrial zones; the electrical engineer dwells on the frontiers where his particular manifestation of energy leads him; the hydraulic engineer is part magician and part meteorologist; and all are inventors.

The structural engineer must spend part of his time denying that he is an architect; but at times has been required to take out a license as an architect to continue his customary practice; the architectural engineer is the missing link.

The practice of all these various master builders is woven together in a single fabric; it forms a single poly-chromatic profession. There is no more reason for excluding the architect from the fraternity of master builders, than for excluding an admiralty lawyer from his legal kin, because his practice has a somewhat different complexion; or of excluding an eye, ear and throat specialist from the balance of medical men because of his particular field.

The strength and welfare of all master builders lie in the solidity of a single great united profession, not in divided counsels. The architects' model law is a proclamation of secession, and menaces fields of practice not territorially belonging to architecture. The structural engineers' law of Illinois was a necessary defensive measure tending further to disintegrate the profession as a whole. Why not an electrical engineers' law, a mining engineers' law, and others, each branch fighting for itself and by itself? In 1861, the secession of certain southern states threatened the Union. Imagine our world power had the theory of state sovereignty prevailed, and this country been broken up into little nationalities like the Balkans! Modern organization is tending towards consolidations, not dissolutions; and the uniform law proposed for all master builders is constructive in its large purpose to end factional divergences and to provide for influential powerful co-operation.

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*From the report of the Engineering Council Committee on Licensing Engineers. This report, made public on Dec. 19, contains recommended uniform registration law for the regulation of the practice of professional engineering, architecture and land surveying. Mr. Shenehon's discussion is given as an appendix to the report.

Perhaps the action of the engineers in writing architects into its uniform bill, may be construed as a little indelicate because architects were not represented on the committee or in the council. But the moulding of a preliminary bill is only one step towards the ultimate bill which may be enacted into law. The bill presented is a text upon which discussion is to be centered to the end that a final perfected bill may be evolved. With the architects' model law, affecting engineers, issued as a perfected document for passage by the various states; and the engineers' bill, affecting architects, still plastic; it is desirable that architects be invited to form part of a new committee to reconcile differences, and write out a single bill.

The architects' model law is not unalterably engraved in stone. A committee's recommended bill, even when underwritten by the concurrence of a large assembly voting for its adoption, is not an unchangeable finality. Men who have dealt with the conclusions of assemblies, know something of the imperfectness of majority votes, which a chance might have swerved into a minority vote; and men who have served on committees know something of the accidental make-up of committees, the preoccupation of the members and the bare margin of judgment on which vital features hinge.

The architects' law in Illinois created bitterness, antagonism and division—internal warfare among the master builders. The engineers' bill may for a time encounter opposition, but as it protects the architect and the engineer without discrimination, and works with the utmost economy in administration for the welfare of all, it is hard to see how it can provoke honest hostility.

The architects' model bill can never become law in any state where engineers are awake to the menace of its provisions, and are organized to circumvent unwholesome legislation. It carries its own death sentence when truly interpreted to a legislature. When architects fully comprehend this fact, perhaps a practicable compromise bill may be agreed upon, which can be supported by all engineers and all architects and has a chance to be enacted into law. Perhaps the smooth functioning of the Michigan law, which includes engineers, architects and land surveyors is tangible evidence of the desirable inclusion of a license law.

Recent Developments in Concrete Testing Methods

The following notes on the work of the U. S. Bureau of Standards are taken from the recently issued report of the Director of the Bureau for the fiscal year ended June 30, 1919:

During the latter half of the year some progress has been made in systematizing and improving the methods of proportioning materials employed in the laboratory for fabrication of test pieces of mortar and concrete, which it is believed will aid in obtaining more accurate and uniform test results. A study has also been made of the effect of variations in the storage and curing of test pieces. A new method has been devised of measuring the "consistency" or "flowability" of concrete, these terms referring to the somewhat indefinite, but very important, property of concrete mixtures which is primarily dependent upon the amount of water used in mixing.

Methods of Proportioning.—Although in the field concrete materials are proportioned by volume, it is essential in the laboratory that weight per cubic foot be known to insure accuracy in duplicating tests and eliminating a variable which may obscure the real differences in strength which should be obtained when comparing different aggregates or in repeating tests with the same aggregate. Often weights are reported as loose weights, determined by allowing the material to fall into the measuring vessel without jarring or tamping. In other cases weights may be reported as packed or tamped weights. The method now employed in the laboratory is to fill the vessel one-fourth of the height and shake and bump until no reduction in volume is apparent, repeating until the vessel is full. The top is then leveled with a straightedge and the net weight determined. The weight used in proportioning and in reporting the result of this test is 95 per cent of the packed weight so determined. Many tests have shown this 95 per cent packed weight to be approximately the average of the loose and packed weights. Since the weight of 94 lb. per cubic foot assumed for cement is approximately an average weight of cement loose and packed, the volume proportions used in laboratory tests are true volume proportions.

Storage and Curing of Test Pieces.—In connection with tests of concrete aggregates, observations have been made of the effect of storage and curing conditions on the compressive strength of concrete up to 28 days. Test pieces molded from the same batches of concrete, in every way comparable, were stored in water, in damp sand, and in a damp closet. In general, it may be stated that under properly controlled conditions these methods are equally satisfactory.

The results obtained varied so slightly that for any one concrete the results of all test pieces could properly be averaged. Temperature conditions under all three methods were practically the same, so that with this sometimes variable factor eliminated it may be stated that any method of curing is efficient which permits all water to be retained in the specimen and permits no evaporation to take place. In a humid atmosphere, such as the damp closet, a sprinkling once daily apparently permitted no essential loss of moisture from the mass. This condition should be especially reassuring and satisfactory to drain tile and other cement-product manufacturers, since it shows that closed rooms kept moist by occasional sprinkling during the curing period, furnish efficient means of storing these products. It should not be assumed from this that additional benefit will not be derived from a well planned and operated system of steam curing.

Flowability of Concrete.—Work which has been done in the laboratory in connection with tests of methods of proportioning concrete mixtures emphasizes most strongly the importance of being able to measure and express the important and fundamental quality of flowability of concrete. In actual work some minimum flowability must be attained, and laboratory concretes should be made with this requirement in mind, since on the job, if the concrete does not have sufficient flowability, more mixing water will be added. Such a property and condition is a necessity, but it is well known that increase in water lowers strength. Therefore, it is essential that aggregates tested in the laboratory should be tested in concretes having the same conditions of flow. Otherwise, misleading and incorrect conclusions will be drawn as to their relative values for concrete making.

In the last annual report a method for determining the consistency or flowability of concrete in the field was described. The apparatus consisted of a piece of cylindrical tubing 6 in. in diameter by 12 in. high, which was filled with freshly-mixed concrete and then withdrawn vertically from the mass. The amount of settling of the unsupported concrete depended upon the amount of water used, and was, therefore, a measure of consistency. This test, commonly known as the "slump" test, was fairly well adapted to the rich mixture employed in ship and highway construction, but was found to be unsuited to the leaner and widely varying types of concrete which are encountered in the testing laboratory.

The flowability is now measured by molding a mass of concrete on a metal-covered table whose top can be raised a fixed height by means of a cam and dropped. The resulting bump will cause the concrete to spread in circular form, concentric with its original outline, the increase in diameter after a given number of repetitions of the bump being a measure of its flowability. Tests to determine the best form of test piece, as well as the height and number of drops, are still under way, but a number of interesting facts are already apparent. It is found that whatever the proportion of cement to aggregate, whether a 1—1—2 mix or a 1—3—6 mix, increase in flowability is proportional to increase in percentage of mixing water. Definite figures for flow can be obtained for concretes too dry for any ordinary practical purposes and also for concretes so wet that they would be ruled off of any properly inspected work. This variation in flow with increase in percentage of mixing water is essentially a straight-line relation within the limit of practical working mixes.

Some work has also been done with an apparatus of this type in determining the consistency of cement pastes, which is a fundamental step in the ordinary testing of Portland cement. While a comprehensive program of experiments has not yet been carried out, it may be stated that the method promises to be of higher merit than either the Vicat or ball methods now prescribed in the specifications.

Steel Erection Methods for Cleveland Auditorium

Towers and falsework, mounted on rollers and moved as a unit, facilitated the erection of the steel work for the new Municipal Auditorium at Cleveland, O. The method is described in the February issue of Successful Methods, from which the matter following is taken:

The installation of about 17 steel trusses 213 ft. in length and each weighing about 15 tons was the biggest problem of the job. Four wooden trestles were built to carry runways and on them were placed two steel towers, back of which was wooden false work on which the men worked while putting the trusses in place. Derricks were mounted on top of the steel towers and were operated by two hoists housed at the base of the towers.

These hoists not only operated the derricks and lifted some single pieces weighing as much as 55 tons, but were employed for the purpose of moving the steel erecting towers and wooden false work whenever a truss was completed and it was necessary to put up the next one. The cable running to the bull wheel of each derrick was detached and fastened to the bottom of the wooden false work, then to the steel towers and finally passed through sheaves attached to the runways. Both towers and false work rest on small rollers, and when the hoists were set in motion, moved as a unit to the new position. The whole operation of moving the equipment required only about 15 min.

This plan of moving towers and false work together proved a most valuable money and time saver. As soon as it was completed the cables would be restored to their normal position and the hoists would immediately resume their regular job of lifting the heavy girders. The task of erecting the steel work, which lasted about 10 months, was accomplished without the loss of a single man through accident, a remarkable record from the point of view of safety.

The United Erecting Co., Cleveland, was in charge of the steel construction.

Personals

Noah E. Holl has been appointed city engineer of Kendallville, Ind.

J. D. Weatherford has resigned as building inspector of Phoenix, Ariz., and will engage in general contracting.

G. B. Brown has been promoted to the position of assistant chief civil engineer of the Cambria Steel Co., Johnstown, Pa.

George F. Turner, formerly assistant surveyor of Mahoning County, Ohio, has been appointed city engineer of Youngstown, O.

J. H. Gilmore has resigned as manager of the Pittsburgh branch of the T. A. Gillespie Co. to enter the firm of Mish & Netherland engineers and contractors of Pittsburgh, with offices in the Oliver building.

H. G. Armstrong, R. R. Simpson and Judson Rucker have organized the Armstrong Engineering Co., Taylorville, Ill., and will engage in engineering and construction.

D. H. Brillhart and **G. R. Brothers** have incorporated and formed the Brillhart-Brothers Co., Inc., engineers and contractors, Bethlehem, Pa. Mr. Brillhart formerly was manager of the fabrication department and Mr. Brothers of the sales department of the Bethlehem Fabricators Co., Inc.

R. D. Whitney, associate professor of engineering at Syracuse University, has resigned, to take effect at the close of the present college year. Prof. Whitney leaves the university to become connected with the H. H. Franklin Manufacturing Co., where he will be attached to the manager's office on special assignments.

William Goldsmith has resigned his position as construction engineer with the City of New York to become president and general manager of the Riverside Construction Co., Inc., at 1440 Broadway, New York City. While with the City of New York Mr. Goldsmith's experiments made possible the using of the city's sewers for the disposal of snow. As superintendent of the Manhattan municipal asphalt plant he organized its operation, introduced the tractor and trailer scheme of transportation and saved $[illegible] to the city [illegible] the first year of its operation. He was also responsible for the complete layout, design and construction of New Hampton Farms (New York City's reformatory for boys) and for the Greycourt Women's Farm Colony. During 1907 to 1910 he was [illegible] engineer for the United States Government in the Philippine Islands. The company with which he is now associated is doing housing development work for private parties in New York City and vicinity.

Morris Knowles, Incorporated, engineers, Pittsburgh, Pa., has consolidated its organization with that of the late R. Winthrop Pratt of Cleveland. The Cleveland office will continue to be operated, but under the name of Morris Knowles Incorporated, and will be under the direct supervision of Messrs. R. F. McDowell and R. E. Garvin, who were continuously associated with Mr. Pratt up until the time of his death. The various branch offices established by each organization will be continued with the possibility of others being added. Although both offices have done important work in connection with water supplies and water purification projects, sewerage systems and draining, Mr. Pratt's organization has had especially helpful experience in garbage and sewage disposal plants, sewerage systems and water works, while Morris Knowles Incorporated has developed strong departments of town planning, industrial housing, flood prevention, valuation and rate making and appraisals. The departments of city planning, industrial housing, valuations and rate making and appraisals will be extended to the Cleveland office, while the departments of design and construction will be materially strengthened in both places. The consolidation results in a personnel of 130 and places the organization of Morris Knowles Incorporated among the largest engineering firms of the United States and Canada.

Obituaries

Dr. Henry Smith Carhart, a famous physicist and electrical authority, died Feb. 13 in Pasadena, Calif.

H. M. Davis, manager advertising department, of the Sprague Electric Works of the General Electric Co., died Feb. 9 at his home in Brooklyn, N. Y., aged 60 years.

Edward A. White, general superintendent of the White Paving Co., Chicago, died Feb. 18 at his home after an illness of three months. His death is the second to occur among officials of the White Paving Co. within a week, William Cooke, vice-president of the concern, having died a few days ago.

Rear Admiral Robert E. Peary, discoverer of the North Pole died Feb. 20 at his home in Washington, D. C., aged 64. Admiral Peary was graduated from Bowdoin College in 1877. He entered the U. S. Navy Oct. 26, 1881, and was assistant engineer of the Nicaragua ship canal. He was made engineer in charge of canal surveys in 1887.

Industrial Notes

The Hydraulic Pressed Steel Co. announces the consolidation of all its interests under the name of The Hydraulic Steel Co. of Cleveland. The executive offices of the company are in the Illuminating building, Cleveland, O., with branch offices in New York Chicago and Detroit.

F. M. Nourse has joined the Charles L. Benjamin organization, Technical and Trade Advertising, Chicago. Mr. Nourse has been engineer in the advertising department of the Cutler-Hammer Mfg. Co. at Milwaukee for the past two years, and prior to that was associated with the Wisconsin Power, Light & Heat Co. at Portage, Wis.

The Plant Engineering & Equipment Co., Inc., New York City, manufacturers of the Corliss valve steam trap, Mason condensation meter and other power and hoisting specialties, announces the opening of its twenty-sixth office. M. Wm. Ehrlich will be the New Jersey manager in charge, with headquarters at Newark, N. J., and a sub-office at Lyndhurst, N. J.

R. E. S. Geare has been appointed general sales manager of the T. L. Smith Co. of Milwaukee, manufacturers of concrete mixing machinery and contractor's equipment. He will be in charge of the company's general sales offices, Old Colony building, Chicago, where the advertising and sales departments are now located. For the past four years Mr. Geare has operated under the firm name of Geare & Co., engineers, specializing in sales engineering in the construction and power plant fields. Geare & Co. handled the business for the T. L. Smith Co., the Manistee Iron Works and others.

The F. C. Austin Machinery Co. has been incorporated to take over the entire business of the F. C. Austin Co. Inc., the Municipal Engineering & Contracting Co. and the Muskegon plants of the Linderman Steel & Machine Co. The combination of the Austin and Linderman plants increases eight-fold the capacity of the present Austin output. The personnel of the companies has been retained. Mr. F. C. Austin, however, has retired from the active management and the president of the Linderman Company, B. A. Linderman, has assumed control. Offices of the combination will continue in the Railway Exchange building, Chicago.

The Advertising Engineers, Inc., 50 Union Square, New York City, has opened an office for the purpose of carrying on the business of counselors and complete service for advertisers of engineering and technical products. C. F. Columbia, C. E., formerly publicity engineer for the New Jersey Zinc Co. and the United States Gypsum Co. and for a number of years closely connected with the metallic industries, will act as eastern manager. Associated with Mr. Columbia are Virgil G. Marani, former building commissioner of Cleveland; Victor Hugo Halperin, Ph. B., formerly advertising manager of the General Fireproofing Co., and F. W. Leggett, E. E., director of publicity of the Bell Telephone Co.

The Indiana Limestone Quarrymen's Association, with headquarters at Bedford, Ind., in anticipation of a year of unprecedented building, has recently been reorganized and expanded with a view to increasing its facilities for serving building construction engineers and contractors. The personnel of the association has been increased and several important appointments made. H. S. Brightly, formerly of Chicago, becomes secretary. George B. McGrath has been transferred from Washington, D. C., and is now in charge of the Metropolitan Service Bureau at 489 Fifth avenue, New York City. C. Roland Yanson has been transferred from Bedford, Ind., and placed in charge of the Chicago Service Bureau at 231 Insurance Exchange, Chicago. W. S. Whyte, with headquarters in Bedford, will cover the middle states territory, succeeding Mr. Yanson. The association's activities in the western field will continue under the able supervision of J. R. Sargent, with headquarters in Topeka, Kans. C. L. Walters has been promoted to the position of secretary of the Bedford Stone Club Auxiliary and C. H. Badgley of Toronto, Canada, will act as manager of the Canadian organization.

Road and Street Monthly Issue

ENGINEERING AND CONTRACTING

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Roads and Streets—1st Wednesday
(a) Roads
(b) Streets
(c) Street Cleaning
(d) Municipal Miscellanies
(e) Management and Office System

Waterworks and Hydraulics—2nd Wednesday
(a) Waterworks
(b) Sewers and Sanitation
(c) Irrigation and Drainage
(d) Power and Pumping
(e) Management and Office System

Railways and Excavation—3rd Wednesday
(a) Excavation
(b) Management and Office System
(c) Quarries and Pits
(d) Steam Railways, Construction and Maintenance
(e) Electric Railway Construction and Maintenance

Buildings and Structures—4th Wednesday
(a) Buildings
(b) Bridges
(c) Harbor Structures
(d) Miscellaneous Structures
(e) Properties of Materials
(f) Management and Office System

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What Is "Economics"?

What does the term "economics" mean? The Committee of Economics of the Society for the Promotion of Engineering Education gave the following definitions in 1918:

> The term economics is taken to mean "The science of wealth." and to deal with matters pertaining to the consumption, production exchange and distribution of the world's wealth as a more or less abstract social science.
>
> Economy of construction, on the other hand, should cover these principles of design and construction, which accomplish desired results with the minimum expenditure of money, all factors being considered, and is founded primarily upon unit costs, maintenance and life of structures, and cost of operation.

It seems to us that a serious mistake was made in defining economics in such a narrow manner as to make it synonymous with political economics.

In the chapter on General Economic Principles in the Handbook of Mechanical and Electrical Cost Data, by Gillette and Dana, the following definitions are given:

> Economy is the judicious expenditure of labor, capital and energy in the attainment of a required end.
>
> Economics is the science of the principles applicable in securing maximum economy.
>
> Engineering economics is that part of economics, applicable in the practice of engineering.
>
> Political economics is that part of economics applicable in political or social management.

These definitions can be improved, but they are substantially in accord with common usage. It is true that professors of political economy have tried to give the word economics the restricted meaning assigned to it by the Committee of S. P. E. E., above quoted. But engineers and business men have not ordinarily used the term economics in such a narrow sense.

There are certain principles of economics that are applicable both in political management and in engineering management, as, for example, the law of reward proportionate to performance. There are certain economic principles that are applicable only in relation to nation-wide economics, such as the "equation of exchange." There are certain economic principles that relate only to engineering design, such as Kelvin's law of economic electric transmission.

The broadest principles of economics are obviously not confined to political management, to engineering management, or to industrial management. Therefore there is justification for a science of economics that is broader than any one of these three branches of economics. To permit political economists to usurp the name economics for their own specialty is no more logical than to permit civil engineers to usurp the name engineering.

"The term economics," says the committee, "is taken to mean . . . a more or less abstract social science." Small wonder that the committee recommended not more than three semester credit hours to this sort of "economics." As a matter of fact political economics has been usually taught

28 Pages=40 pages

The 28 pages of articles in Engineering and Contracting contain as many words as 40 pages of the size and typography commonly used by other engineering periodicals. Ours is the same size of type and typepage as that of The Literary Digest—easily read, yet giving a large volume of reading matter per page. Our 28 pages of articles would fill 112 pages of the standard 6x9 in. text-book. It would take 10 such books of 580 pages each to hold all the articles printed each year in Engineering and Contracting, to say nothing of our weekly construction news.

as if it were an "abstract social science," instead of as a practical science of social management. But the day of that sort of teaching is coming to an end. Social or political economics will be regarded as a highly practical subject with which every educated man should be somewhat conversant. Upon engineers in particular will it be incumbent to understand the economic laws that relate to increasing the income of workers taken as a whole.

Labor unions in two great industries—coal mining and railroading—are strongly in favor of nationalizing those industries. They favor this radical step because they believe their incomes will be increased if it is taken. Hoover has already indicated how the annual income of the coal miners can be greatly increased without nationalizing the coal mines; and he urges mining engineers to solve this national economic problem completely. Perhaps some civil engineer will parallel the plan of this great mining engineer, and show how to increase the income of the average railway employe even beyond what such an employe hopes to receive under government ownership.

Engineering and political economics overlap, because they have general economics in common. Let there be no further confusion as to the existence of a science of economics that is broader either than engineering or politics.

The Spendthrift Theory of High Prices

As soon as the average man is elected or appointed to a prominent political office he becomes imbued with the idea that he can solve problems in political economy offhand. He regards his official title as the equivalent of a college degree certifying to proficiency. It matters not that he has never read a single treatise on political economy. Why waste time on the dreary tomes that Adam Smith, or John Stuart Mill, wrote? Those old English fossils could not teach a modern American anything any way.

Typical of the average politician in this respect is the new secretary of agriculture, Edwin T. Meredith. In a recent address before the Association of Commerce of Chicago, Mr. Meredith said:

> Hi Cost is a development of an abnormal state of mind. Food today should be as cheap as it was six years ago, if not cheaper. More food per capita is being produced here than ever before. We have become a nation of silly spendthrifts, and the result is we are being trimmed right and left by everybody and anybody. We are the superfools of the world.

Had Mr. Meredith been even slightly acquainted with political economy, he would not have made such a "superfool" utterance, for he would have known that price levels depend upon several factors, of which production is only one. Every political economist of note regards the per capita quantity of money as being one of the factors that determine average prices.

If per capita productivity remains constant while per capita money increases, say x per cent, then average prices will rise x per cent. Blissfully ignorant of the "equation of exchange," Mr. Meredith looks at only one factor, namely per capita production, and in only one field (agriculture); then he "superfoolishly" declares the entire nation to be "the superfools of the world" because it is paying nearly twice as high prices for food as in 1914. Americans may be fools, but hardly "superfools," as the following table from a November issue of the Manchester (Eng.) Guardian shows:

	Currency (Pre-war 100).	food prices (Pre-war 100).
United States (May, 1919)	173	181
Switzerland (June, 1919)	230	250
Denmark (July)	240	212
United Kingdom (August)	244	217
Netherlands (September)	270	203
Sweden (April)	275	336
Norway (May)	305	271
France (June)	365	293
Italy (April)	440	281

We see from this table that food prices had risen 81 per cent in the United States in May, 1919, compared with prewar prices; and that the volume of money had increased 73 per cent during the same period. A similar relation of food prices to currency is to be found in all the countries. There is nothing novel about this phenomenon. It was pointed out by John Locke more than 200 years ago that prices are affected by changes in the quantity of money in circulation.

"Why the Dollar Is Shrinking," by Irving Fisher, professor of political economy at Yale, gives an outline of the "quantity" theory of money, together with data that prove the theory to be sound. The book is published by MacMillan & Co., New York; its price is only $1.25. We commend this book to Mr. Meredith and to all others who attribute present high prices to general spenthriftness. We also suggest that the advocates of the spenthrift theory look up statistics on the annual increase in capital in this country. It may surprise them to learn that the people have been saving as great a percentage of their income during the last five years as ever before—in short, that their spendthriftness has not increased.

An Opportunity for California Engineers to Serve the Public in a Striking Manner

Road bulding programs in several states are not likely to be carried out in full because highway bonds bearing low interest rates are not readily marketable in these days of high interest. The California Highway Commission, for example, had planned to spend about 10 million dollars this year, but the highway bonds are limited to 4.5 per cent interest. When U. S. "liberty bonds" can now be bought at prices that yield 5 per cent, there is little chance of marketing state bonds that yield less. Moreover, there are millions of dollars' worth of public utility bonds offered for sale at prices that will yield the investor 6 to 7 per cent.

It seems to us that the engineers of California should take the initiative in a publicity campaign to bring about an increase in the interest rate on state bonds. To accomplish this may require a special session of the legislature. It may even involve a vote of the citizens of California. But in any case the public expense will be warranted by the public benefit that will accrue from the carrying out of the 40 million dollar state highway program.

Let no one be deluded by the hope that interest rates will soon return to the old level. Every great war has been followed by high interest rates that have remained high for years.

If California waits a year to sell state highway bonds, she will still face more years of waiting after that.

The engineers of California should secure the aid of automobile clubs, chambers of commerce and the like, in a publicity campaign that will speedily bring about the sale of highway bonds bearing interest rates that will attract buyers.

Special Devices for Corrugating Concrete Base to Prevent Creeping of Bituminous Concrete Surface

A considerable yardage of sheet asphalt pavements at Trenton, N. J., has been laid directly on the concrete base, the binder course being eliminated. In this work a special tamper designed by Mr. A. Swan, Jr., the City Engineer, was used on the concrete. By means of this tamper the base was corrugated deeply and uniformly at right angles to the traffic. It is said that there has been no creeping of the asphalt wearing surface under heavy use for two or more years.

A somewhat similar method of locking the bituminous surface to the concrete base employed in the Borough of Richmond, New York City, is described by Mr. Theodore S. Oxholm, Engineer in Charge of the Bureau of Engineering of the Bureau in a paper presented last month at the convention of the American Road Builders' Association. The concrete consisted of 1 part cement and 6 parts trap rock screenings. For corrugating the base a roller was made of a 2½-ft. section of telegraph pole with bands of 1 in. round iron fastened around it and spaced 4 in. on centers; a long pole attached so that the roller could move easily completed the outfit. The water was squeezed out of the concrete by a light roller such as is used for concrete pavement, and then as the concrete was beginning to set the corrugated roller was rolled across the base once for each section. The result was most gratifying, as a perfect series of depressions appeared 1 in. deep and 4 in. apart, uniform in character and extending the whole width of the base.

Is a New Organization Necessary to Further Non-Technical Interests of Engineers?

To the Editor: Permit the writer to express his unqualified approval of united action in matters relating to the non-technical interests of engineers as discussed by C. E. Drayer in his letter appearing in the Feb. 11 issue of Engineering and Contracting.

It is evident that the purely scientific societies, governed by men "distinguished by research and technical achievement" have their hands filled to overflowing with the duties of giving rank and file engineers safe and sure technical guidance.

The necessity for the united action of all engineers on social and economic problems is now so plain and evident that there is no need of wasting rehtoric on the subject. The engineer of the rank and file who is not now interested in the work of the American Association of Engineers has evidently not been informed that "the Lord helps him who helps himself." The writer suggests that such engineers look up the history of the past accomplishments of the American Association of Engineers in matters relating to the social and economic betterment of the profession and further read a statement of its aims. It might be well also to glance over the membership.

The A. A. E. has among its members a number of men who are not only "distinguished by research and technical achievement" but who are also "distinguished by achievement unmodified." With the assistance and guidance of these men, engineers have the best chance they have ever had for social and economic betterment.

These things cannot be accomplished in a day nor in a year, and furthermore they require the active co-operation and backing of all engineers. What is accomplished will benefit all engineers. No real engineer should sit passively by and "let George do it." Engineers, especially we of the rank and file, must have patience, faith and foresight.

The writer believes that all engineers should get into and behind the American Association of Engineers and boost, feeling safe and sure in the guidance of the leaders in the association who need no introduction to anyone.

R. W. TRULLINGER.

Washington, D. C.

To the Editor: While the rank and file of the engineering profession may, with good reason, rejoice on learning that the governing boards of the founder societies and the American Society of Testing Materials by their action at the joint conference of Jan. 23 adopted in principle the Development Report, yet for many the pleasure this news will create is largely that coming from a realization that many of the more conservative members of the profession have seen the light and have come to recognize not only that there is need for attention to matters of general moment to the profession which are outside what is generally regarded as the sphere of primary activities of what may be termed technical engineering societies, but also that these conservative ones see the necessity for a great national organizaton whose activities shall be towards the solution of those problems, non-technical in character, which may speak for the great mass of the profession.

The form of organization proposed in the Development Report is virtually a federation of existing local, state and national societies. The history of féderations in general is a record of inefficiency, of groups seeking to gain advantage over groups, of distrust, discord and compromise and the jealousies of the individual groups sooner or later lead to practices which either render useless the federation or cause its complete collapse. Of course it is possible in the present instance that the usual difficulties will not be encountered, yet on the whole there is no reason why history should not repeat itself; and for this reason not a few of the thinking men of the profession, members of the founder societies as well as non-members, regard the formation of an organization along the lines proposed as a questionable, if not a dangerous experiment, an experiment which will neither lead to the solidarity of the profession nor to an increase in the present usefulness of any of the professional societies of which it would be composed.

As one holding membership in one of the founder societies I may say that I feel that it would be a mistake for this society which, since its organization has served so well the technical needs of its special branches of engineering, has done so much to advance our knowledge of the forces of Nature and the use as behavior of materials and in other ways sought and made engineering a learned profession to "adopt the principle of becoming an active national force in economic, industrial and civic affairs" or to actively co-operate in the creation of the federation proposed in the Development Report.

Rather I feel that these societies should restrict their primary activities to such matters as have held their attention in the past and that as societies should co-operate in the furthering of this movement for an all-inclusive welfare organization of engineers only to the extent of endorsing the general form and activities of such an association, leaving the financial support to their individual members.

With it clearly recognized by the great mass of the profession that there is need of a truly representative, all-inclusive engineering association to look after our non-technical interests, and with it most evident that there are advantages in such an association composed of individuals rather than of groups, truly democratic in character and inviting the confidence of the rank and file of the profession, it seems to me both logical and fair to inquire as to whether there be not in existence some living society whose avowed objects and activities are harmonic with those proposed in the Development Report.

I believe in giving credit where credit is due, and I believe in using existing machinery rather than trust to untried devices when such is possible. However much any of us may belittle the early history of the American Association of Engineers, we can not but admit that not only has it been a vital factor in awakening the older national societies to the need for action along the lines it is pursuing but also has during the past year established a record, not only in increase in membership and in attracting the thinking men of the profession to its ranks, but in welfare activities, which stand pre-eminent in the history of society achievements. Its form of organization seems to be almost ideal, and it is democratic to the core. And a few would venture to say that it does not command the confidence of the rank and file of the profession.

I can see no logical reason why this association should not form the nucleus of a larger, more truly representative, more powerful, more efficient and more enduring welfare organization than that proposed in the Development Report, and I believe that a joint conference of the governing boards of this association and the founder societies might be productive of an exchange of ideas which would at no distant date bring about the founder societies' endorsing the objects and methods of the American Association of Engineers, the founder societies being relieved of all direct support in the movement except for the maintenance of advisory committees. It is conceivable by such procedure and the active support of individuals of the older societies that the growth of the American Association of Engineers would be nothing short of marvelous and that within a very short time we should have the thing sought without duplication of effort and without interfering with the primary activities of the older national societies. And I can not see how such procedure can either weaken the prestige of the founder societies or fail to affect a closer unity in the profession.

RAYMOND E. DAVIS,
Associate Professor, Civil Engineering
Department, University of Nebraska.

Lincoln, Neb.

Cost of Road Surveys

To the Editor: In the Feb. 4 issue of Engineering and Contracting is an article explaining the arrangements by which Missouri is to have its highway engineering performed. The price of survey and plans has been fixed by law at $100 a mile. It seems that some surveying has been done at a cost of about $75, "leaving $25 a mile for the completion of the plans."

Whoever set the price of survey and plans at $100 a mile was woefully lacking in data on the cost of this kind of work. The people who can get the surveying at $75 a mile need no sympathy—at that price there is a large profit—the people who will need sympathy are those who shall try to turn out the office work for $25 a mile.

The requirements of Federal Aid and the State Highway Commissions are, in some instances, rather exacting, and it would be well for private engineers to exercise caution in taking contracts on the strength of data such as quoted. In one instance an engineering firm "broke even" on a 22-mile job at $225 a mile. Another job of 29 miles will pay a small profit at $175 a mile. The high cost in the first case was caused by breakage in an organization. In both these jobs were included the design of culverts and of bridges up to 20 ft. span.

To give an idea of the work involved in the preparation of plans I will cite one job of 33 miles that required 246 sheets (22 in. by 36 in.) of cross-sections, maps, and culverts and bridge designs to properly comply with the requirements laid down.

The principal complaint against disseminating the idea that highway survey and plans can be made for $100 a mile is the effect on engineering firms engaged in this kind of work. They are met with the belief, implied if not expressed, that they are bold robbers for asking $175 to $200 a mile for the work.

Kansas City, Mo. C. O. SANDSTROM.

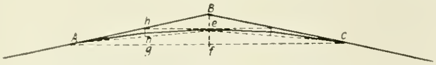
"Rule of Thumb" Method for Determining Street Crown

To the Editor: I notice in the issue of Feb. 4 a table by J. A. Lilly for computing vertical curves connecting two intersecting grade lines, and I wish to call attention to a long-used approximation based on the rule of thumb for street crown in use by paving contractors of the old school.

This approximation is based on the assumptions:

First: That the deflection angle at the point of tangency is proportionate to the tangent of the angle, which is very nearly true for such small angles as are generally encountered in such work.

Second: That no appreciable error is introduced in the case of grades ordinarily encountered by assuming the vertical correction to be identical with ordinate as computed.



In the above diagram, from these assumptions, compute the elevation of the point f at the average between the elevations of points A and C, A and C being equidistant from B, the point of intersection of the tangents.

Average the elevations of points B and f and we have the point e on the vertical curve.

Proceeding in like manner select a point one-half way between A and e, compute the elevation of h on the tangent, average the elevations of e and A and average this elevation with the elevation of h, the result being the curve elevation n.

In this manner any number of points can be determined, the curve being split into any number of parts in multiples of two, by merely bearing in mind the fundamental principle on which the curve is computed.

With a known height for e, the height of f can be computed and the distance AB or AC determined by a few trials so that the curve may be established at the elevation desired.

The approximations introduced by this method give a curve slightly higher at e than a true circle, and this is also true at n, but the curve is believed to be fully as accurate as the uncertainties of construction methods warrant.

S. L. MOYER.

Montevideo, Minn.

$60,000,000 Road Bond Issue for Missouri.—Governor Gardner of Missouri is advocating a plan to capitalize the state motor car license revenues and create a road fund for immediate use of $60,000,000. It is proposed to vote at the November, 1920, election on an amendment to the constitution to authorize the issue.

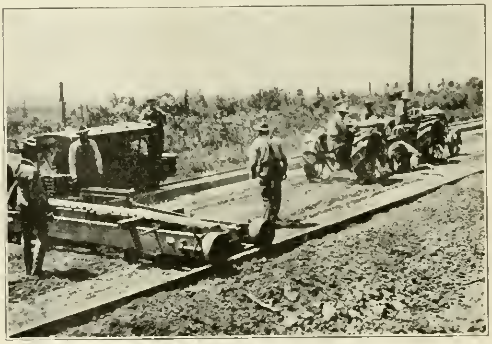
Equipment for Concrete Road Construction

By B. H. PIEPMEIER.

Construction Engineer, Springfield, Ill.

The essentials of a good concrete pavement are: A well-drained and uniform subgrade; thoroughly mixed concrete with good aggregates; a uniformly finished pavement absolutely free from ridges or depressions and uniformly well-cured. Any equipment that will enable the contractor to lay a large volume of pavement complying in every detail with the fundamentals listed above will insure success to the contractor and favor with the engineer.

Subgrade May Be Prepared by Using Scarifier Attachment on Road Roller and by Means of Special Drag That May Be Guided by the Side Forms.

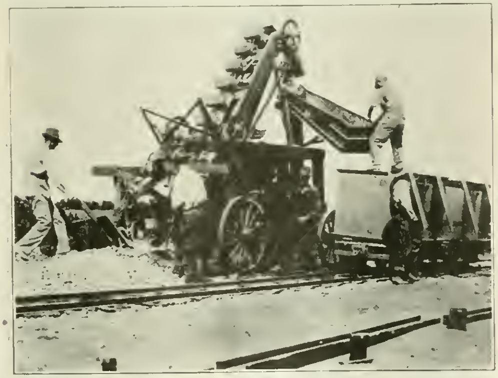


Subgrading Machine Operated After Forms Have Been Set to Grade.

Equipment for Unloading from Cars to Storage. All Materials Are Stored on Top of Tunnel Thereby Enabling Batch Boxes to Be Filled Without Rehandling of Material.

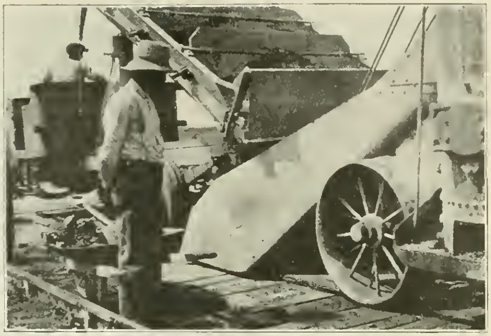
Bins, Storage Piles and Material Plant for Industrial Hauling.

Money is the chief ambition of every contractor. Therefore the equipment that will net the greatest return is essential. The concrete mixer is the most essential machine on any paving job; therefore, every possible effort should be exerted to keep it going at all times and to its full capacity. The economy of any paving mixer depends almost directly upon the methods used in the transportation of materials to or from it. Considerable study should therefore be given to every paving job to insure regularity and economy in the delivery of all materials.



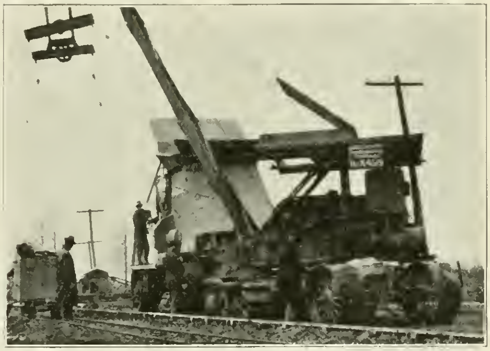
Mechanical Device for Loading Materials from Storage Piles Along the Road.

Conveyor Belt Used for Charging Skip on Paver. Materials Shoveled from Storage Piles or from Subgrade.



Mixer Being Charged from Batch Compartments in Truck Bodies.

When aggregates are transported by teams or motor trucks the materials should be placed upon the subgrade or in storage piles at intervals along the road. Trucks or teams cannot always be depended upon for regular delivery on account of road conditions; hence, a large storage should be provided upon the subgrade or in piles to insure operating the mixer to its capacity. When materials are dumped upon the subgrade the paving mixer may be charged by a conveying belt, wheelbarrows, or by light industrial carts. A 4-bag paver is usually the limiting size when it is charged in this way.



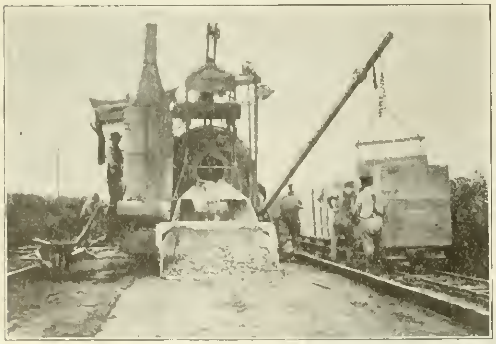
Eight Bag Paver Being Charged from Batch Boxes Delivered by Industrial Equipment.

When materials are stored at intervals the mixer may be of the paver or stationary type. When the paver is used, it can be charged by using batch boxes that are transported by industrial track from the storage piles to the mixer. When stationary mixers are used they can be charged by some mechanical device at the storage pile and the mixed concrete delivered by industrial equipment, by street carts, or specially-designed trucks. Material stored at intervals along the road has some advantage over material strung upon the subgrade as it saves loss of aggregate, leaves the subgrade undisturbed, and permits many labor saving devices.

When materials are transported by truck, they may be stored as described above. However, where road conditions permit undisturbed operation of trucks, the material may be delivered directly to the paving mixer or the mixed concrete delivered directly to the road from a central mixing plant. Where materials are not stored on the road, an efficient procedure is to use light trucks (2-ton or less with pneumatic tires) to deliver the concrete from a central mixing plant. Such a plan will permit of an economic plant and a very large output. Where the contractor wishes to use his trucks and the road conditions are doubtful or will not permit of regular daily use of the light trucks, the subgrade should be thoroughly oiled early in the spring. The oil will prevent dust and mud and will enable the road to be used a great many more days during the construction season. A 1 or 2-ton truck is preferable where earth roads are encountered. Where the old road bed is of gravel or stone and regular delivery of material is not necessary to keep other parts of the work going a heavier truck may be used with some success.

On road work where the grades are less than 4 per cent and on roads that are generally more or less affected by weather conditions, the complete industrial equipment for hauling all materials probably will prove to be more economical and satisfactory to all concerned. Industrial equipment is very expensive and a contractor's success with it depends very largely upon the way his forces are organized and the kind of equipment used on other parts of the job. Where industrial equipment is used, all other functions of work should be so operated as to work the industrial equipment to its capacity.

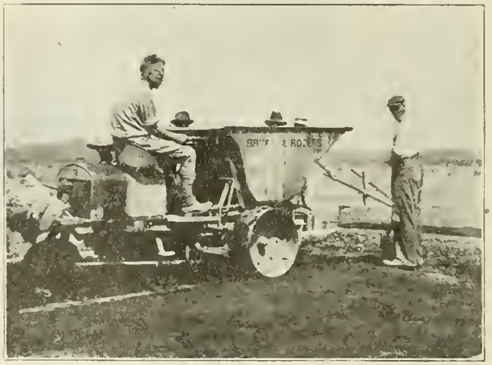
One line of industrial track will carry more material than a 1, 3, or 4-bag concrete mixer will handle; therefore, two or more mixers should be used or one very large unit such as an 8 or 10-bag paver. The large single unit is preferable to 2 or more smaller units when industrial equipment is used, as the larger unit will take but few more men to operate it and will keep all work centralized. The limiting capacity of the mixer, therefore, should be determined only by the limiting load that any one industrial car will carry economically.



Four Bag Paver Being Charged by Batch Boxes Delivered by Industrial Equipment.

In the design of any plant or transportation method, the hauling of mixed concrete should not be disregarded. Experience has shown that mixed concrete may be transported 4 or 5 miles successfully and economically. Central mixing plants permit more centralized control and more efficient operations in many cases and should therefore be given full consideration by contractors who are selecting new road-making equipment.

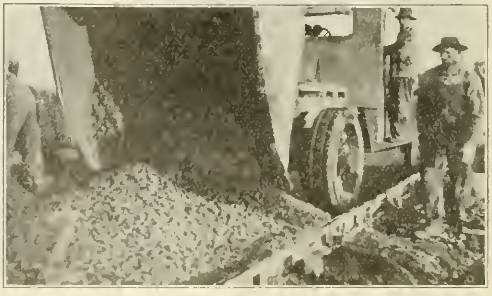
"Stationary" Mixing Plant Moved to Piles of Material Stored Every 600 to 1,000 Ft. Along the Road. Mixer Is Charged by Clam Shell That Picks Up Material from Storage Piles. Concrete Is Delivered to Subgrade by Carts or Special Trucks.



Specially Designed Trucks Used for Delivering Concrete from Field Mixing Plants to Subgrade.

After the contractor has decided upon his method of transportation, the material yard and unloading plant should be selected to fit the method of transportation chosen.

When teams are used for hauling, hand unloading frequently proves to be very satisfactory if labor can be secured although the clam shell permits of greater storage and of other mechanical labor-saving devices. Where the clam shell is used for unloading, bins or tunnels should be provided so that materials may be conveyed to the hauling units or mixer at the minimum cost. Tunnels are much more satisfactory than bins, as they permit greater storage and economy in operation.



Mixed Concrete Delivered from Central Mixing Plant Direct to subgrade by Motor Trucks.

In a few instances conditions at the unloading site will permit a trestle to be built where hopper bottom cars may be elevated and their contents dumped into bins or upon a tunnel. Such an arrangement for unloading materials is very satisfactory and economical.

All of the essential equipment for concrete road construction cannot be enumerated on account of the variable conditions that are encountered on every job. There are, however, a few machines that are generally essential and should be provided by the paving contractor to insure economical results. They may be listed as follows: A mechanical tamping and finishing machine; a power subgrading device; a duplex pumping unit with sufficient 2-in. or 3-in. pipe to supply water for the average paving job; a power roller with scarifier attachment where possible; a 1-bag mixer for bridge and culvert construction; two or more light tractors and trucks for incidental hauling and pulling; a light road grader; wheelers, slips and fresno scrapers with other incidental equipment essential to all contractors plants.

The Local Engineering Organization and Participation in Civic Affairs of the Community

An excellent example of the real benefit which local organizations of engineers can confer upon a community by active participation in civic affairs is given by the recent action of the Tacoma Chapter of the American Association of Engineers in making a report on the types of paving used in Pierce county as a means of settling the dispute regarding expenditure of pubilc funds for street and road improvement. Pierce county, in which Tacoma is situated, recently bonded itself for $2,500,000 for paving roads. When the first call for bids was issued a controversy arose concerning the type of pavement to be used. This resulted in a warm argument, but one in which the newspapers had not taken sides.

The report of the chapter did not recommend any particular type of paving, but discussed various types from a standpoint of construction cost and depreciation. Various comparative data were included in the report, which holds that "power to determine the type of pavement should be vested in the engineer. The engineer alone should select the type, form, and thickness of the pavement to be used, and should be permitted to vary the plan of construction even in the several parts of the same highway so as to best overcome difficulties and take advantage of local conditions. The report was prepared by F. J. Walsh, consulting engineer, Port of Tacoma; F. H. Cushman, assistant engineer for the city of Tacoma, and J. A. Pritchard, assistant engineer for the County of Pierce.

This report resulted in an editorial in The Tacoma Ledger favorable to the policy recommended. The editorial is entitled "Paving with Horse Sense." "We take it," say The Ledger, "that they do not advocate that every road be paved with concrete or that every road be paved with bitulithic, but that all roads be paved with horse sense. One can not read the report without feeling that whoever wrote it was doing the work without prejudice." The editorial discusses the remainder of the report and commends it most highly.

Montana Road Projects for 1920.—The Montana State Highway Commission of which John N. Edy, Helena, Mont., is chief engineer, has issued a bulletin for contractors outlining its Federal Aid program for the present year. The work listed includes 740 miles of grading or regrading, 544 miles of grading and surfacing with gravel; and 343,000 sq. yd. of pavement. A considerable amount of bridge work also is included. It is anticipated that lettings will be held at 2-week intervals through March, April and May.

Registration of Motor Vehicles in Pennsylvania.—It is expected that previous automobile registration figures in Pennsylvania will be greatly surpassed by the registrations for 1920. On Feb. 21 the automobile division of the State Highway Department passed the 275,000 mark in the registration of pneumatic-tired vehicles and the 40,000 mark in the registration of solid-tired vehicles. The total registration in 1919 was 482,117, of which 441,224 were pneumatic-tired vehicles. The total receipts in 1919 were $5,090,646.

Piece Work System of Paying for Odd Jobs on Concrete Paving Work

By R. F. HOFFMARK,

Western Superintendent, A. Guthrie & Co., Inc.

On most concrete paving jobs the general construction methods are planned well in advance of the starting of the work, and if sound principles are followed the biggest problems are successfully solved. Thus the questioning of delivery of materials, preparation of the subgrade, form construction, water supply and mixing plant are all lined up and worked out in detail before actual work begins. As a general rule, however, incidentals are left to take care of themselves or put up to the individual foremen to solve. And these incidentals are generally very troublesome and may be the cause of considerable loss on the job. Very frequently, if the incidentals are not properly planned, the progress of the entire work suffers.

On concrete paving jobs in Oregon these incidentals may be listed as follows

Unloading cement.
Covering newly laid pavement.
Sprinkling newly laid pavement.
Shoulder construction.

If sand and gravel are stored on the subgrade and loaded into the skip of a mixer by the wheel-barrow method, the question of keeping a full gang on the charging end of the mixer is also a very troublesome one.

On the Hillsboro-Multnomah county line job in Washington county, Oregon, described in Engineering and Contracting, Feb. 4, a number of experiments were tried in an effort to determine the best way to line up incidentals. At the start of the work all these various operations were performed by day labor. This was found to be very unsatisfactory, both as to high cost and the difficulty of maintaining full crews. As every contractor knows, it is most difficult to hold men on the crews that are unloading cement. The men might stay at a high wage rate, but such a rate would have the effect of unbalancing the entire wage scale on the work. On the work mentioned, a record was kept from the very beginning of the cost per sack of unloading from standard gage cars, and reloading on narrow gage equipment. A record was also kept of the labor turn-over in the cement house. Frequently it was necessary to take men from the grading, fine finishing or mixer gangs to replace men quitting in the cement house, and it soon became evident that the cement handling operation must be permanently solved because of the disorganizing effect of transferring men from gang to gang. Accordingly prices per sack propositions were made to several gangs of from three to five men. The duties were outlined as consisting of: unloading from box cars, either directly to the narrow gage cars or into the cement store-house, shaking empty sacks, counting, bundling and loading empty sacks for shipment back to the cement plant. The price finally established was 2 ct. per sack, and it was found that two men could easily supply a shift using as high as 1,200 sacks.

The two men selected staid all summer, earning as much as $12 per shift. A remarkable performance was given during the last two weeks, when one of the partners quit and the other assumed all of the duties alone, handling as many as 1,000 sacks per shift. It is needless to say that the man was practically "all in" at the end of this period.

The matter of covering the pavement gave trouble due to the fact that the days' runs varied, and a different number of men were required for each day, also, without a foreman the efficiency of the men was low. The covering, therefore, was incorporated in a contract for the construction of the gravel shoulders. Seven men took this contract, which consisted of excavating for the 2 ft. shoulders, placing the gravel, covering the gravel with earth, trimming side slopes and covering each day's run of pavement. Gravel for shoulders was delivered by narrow gage trains and dumped in piles on the finished pavement. During forenoons they covered the previous day's run and in the afternoon worked on shoulders. Payment was made on engineer's measurements at a price per lineal foot for covering, and a price per lineal foot for shoulders. This crew staid all summer, the men averaging about

$175 net per month. This crew worked independently, all men being equal partners, and required no supervision.

Numerous attempts were made to handle the sprinkling in the same manner, but, owing to the fact that the amount of sprinkling required was entirely a matter of judgment on the part of the inspector, it was found impossible to sub-contract this operation satisfactorily.

On this work 6,000 ft. of pavement was laid by the old method of storing sand and gravel on the subgrade and charging the loading skip with wheel-barrows. Difficulty was encountered at once in keeping the charging crew filled up because as soon as the foreman made an effort to crowd the work men would quit and leave him shorthanded. A crew of eight men were gathered with the purpose of interesting them in taking over the work of charging the mixer on a contract basis. They were given an opportunity to get acquainted with the proposition by working three days at a daily rate and were then made an offer of 12½ ct. per square yard of pavement laid. As soon as they went on the contract basis the output of the mixer increased. The spreaders and finishers were retained on a daily basis because it was felt that if this operation was contracted, the work might be slighted. The duties of the contract crew consisted of charging the mixer with sand, gravel and cement, and bundling the sacks for shipment. The same crew finished the work and averaged about $9 per day.

The main advantage of the small contracting system lies in the fact that the labor situation is stabilized and the entire paving operation is, therefore, more continuous.

Operating Cost of 20-Ton Caterpillar Tractor in Snow Removal Work

Ten Holt Caterpillar trucks have been operated in Michigan during the present winter on duties incidental to snow removal and the keeping of state trunk line highways open for traffic. These machines are equipped with a 120 hp. motor and are rated as a 20-ton tractor, their weight being 13 tons. The following statement from a bulletin of the State Highway Department shows the operating costs for a 2-weeks' period for one of those tractors, used in pulling snow roller and plow:

Gasoline, 175 gal. at 25 ct.	$ 43.75
Lubricating oil, 36 qt. at 17 ct.	6.12
Grease, 3 lb. at 12 ct.	.36
Alcohol, 20 gal. at 90 ct.	18.00
	$ 68.23
Labor, 52 days at $4.00	208.00
Total	$276.23

Number of miles of road opened, 55.2.
Unit cost per mile of road, $5.004.

The above costs do not include fixed charges. There were no repairs or renewals during this period.

Census of Special Information Sources

The Special Libraries Association is now enumerating the special library collections, with a view to having in a central place a record of the special information sources of the country. By special library is meant "a good working collection of information either upon a specific subject or field of activity. It may consist of general or even limited material serving the interests of a special clientele, and preferably in charge of a specialist trained in the use and application of the particular material."

If your library comes within the above qualifications the S. L. A. will appreciate the following information:

(1) Name of institution or company.

(2) Name by which library is known.

(3) Name of librarian or custodian.

(4) Can it be classified as any of the following: Financial, business, legal, engineering or technical, institutional, municipal, reference, agricultural.

(5) If not, how can it be classified?

(6) Does it serve a special clientele?

(7) Would your librarian be willing to assist other special libraries to a reasonable extent?

The above data should be sent to Wm. F. Jacob, Chairman Library Census Committee, % General Electric Company, Schenectady, N. Y., who will be glad to answer any questions relating thereto.

Laboratory Tests of Granite Paving Block and Suggested Specification

By F. H. JACKSON,

Senior Assistant Testing Engineer, U. S. Bureau of Public Roads.

For a number of years it has been the custom of municipal engineers to include in specifications for granite paving block construction requirements covering the quality of the block which are based on certain laboratory tests. As a general proposition this is good practice, since it is almost universally recognized that specifications for quality, based on tests which have been designed for the purpose and properly conducted, go far toward insuring the use of correct materials in any piece of construction. Unfortunately, however, none of the tests which have been used to determine the quality of granite block were designed for this specific purpose. Instead, methods were adopted which were already in use for testing either building stone or crushed rock for macadam road construction, with the result that there has always been a great deal of uncertainty among both producers and users of granite block as to the significance of the results obtained from time to time. This has led, not unnaturally, to a disposition on the part of many engineers to ignore the results of laboratory tests on this material, and it must be acknowledged that some of their criticisms have been justified.

Commonly Used Tests Are Unsatisfactory.—The more commonly used tests for granite block are crushing strength, toughness and abrasion. In the opinion of the writer, none of these tests is satisfactory as they are now conducted. The reasons for this are not far to seek. In the first place, the compression test, although formerly used extensively in connection with tests of building stone, has never been standardized. Wide discrepancies have been noted when identical materials have been tested by different investigators or when tested by the same laboratory using different methods. Over 100 per cent variation has been repeatedly found in the ultimate crushing stress developed in the same material when tested under different conditions. It is obvious that anything like precise results for this test are impossible until it has been properly standardized. On the other hand, the toughness and Deval abrasion tests, although standardized as to method*, were originally designed to determine the relative resistance to impact and wear of stone to be used in macadam road construction. Both tests have in the main proved satisfactory for this purpose. This is no reason for assuming, however, that either is satisfactory for granite block testing. As a matter of fact, both tests are of doubtful value. In the first place the extreme range in resistance to wear and toughness shown by granite as a class is small, compared to the total range in these qualities shown by road-building rock in general.

For instance, the records of the Bureau of Public Roads show that total range in the coefficient of wear when considering road-building rock in general is from about 3.0 to 25.0, whereas the corresponding range considering granite block alone is only from about 8.0 to 12.0. Likewise, the extreme range in toughness for all rock has been found to be from 3 to 60, whereas the corresponding range for granite block is only from about 7 to 15. Numerous experiments have shown that the probable range of error in testing for the coefficient of wear by the standard method is about 1.0, while for the toughness test it is about 2. This simply means that when testing for the coefficient of wear or toughness by the old methods a tolerance amounting to 25 per cent of the entire range in values found for this material must be allowed to cover errors in testing.

Those familiar with the details in making these tests will realize why it is impossible to obtain closer check results in the laboratory on identical samples. In the case of the abrasion test the sample is broken into small fragments by hand, and while every effort is made to have these fragments as nearly cubical in shape as possible it is very difficult to prepare two samples just exactly alike. Inasmuch as the percentage of wear depends to a very great extent on the shape of the fragments composing the test charge, it will be seen that this variable might account for considerable differences in the results obtained.

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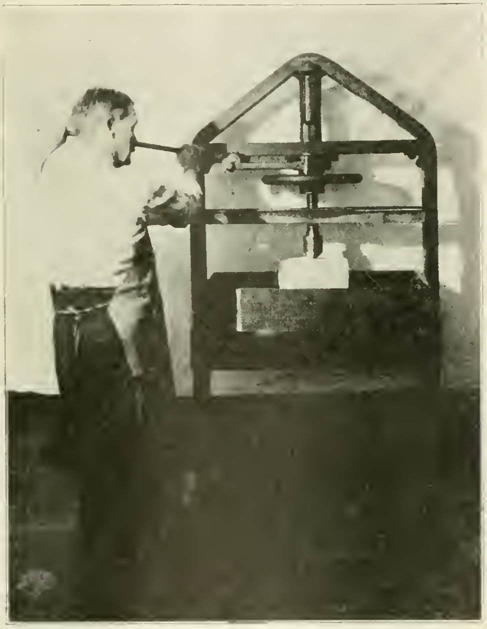
*For a description of the standard methods, see American Society for Testing Materials Standards, 1918, pp. 623 and 625.

In the case of the toughness test the extremely small specimen used, 1 in. high by 1 in. in diameter, and the consequent necessity for absolute accuracy in preparation and testing, makes it very hard to obtain absolutely check results. When it is realized that the range in values of granite block given above include tests from every commercial quarry in the East it may readily be seen that more accurate tests than the ones now in use will be required before a trustworthy comparison of the results can be attempted.



General View of Press, Showing Method of Operation.

The standard Deval abrasion test has likewise been criticized from another point of view. Many producers claim that the process of breaking the rock into small fragments by hand with a stone hammer induces insipient fracture in the stone which is not present in the quarry-made block. This objection would, of course, not apply in the case of stone for use in macadam road construction because of the fact that if insipient fractures are formed at all it is during the processes of blasting and crushing. It must, however, be considered as a possibly valid objection in the case of granite block testing.

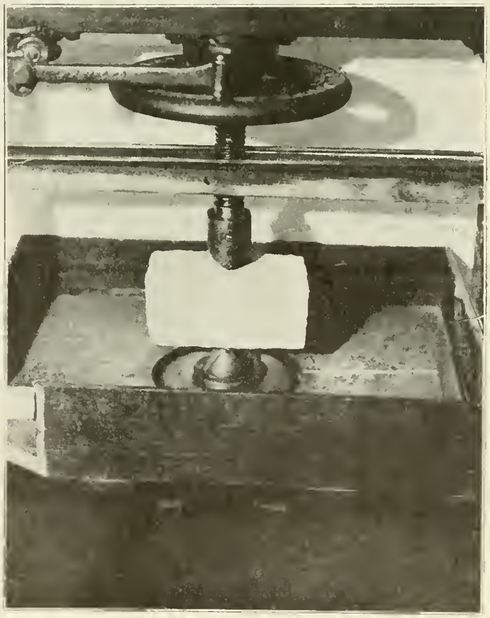
Granite Block Testing Experiments of Bureau of Public Roads.—With the above facts in mind a number of experiments have been made recently in the laboratory of the Bureau of Public Roads with a view of modifying the standard Deval abrasion test so that it could be used for granite block testing. It was felt that, for a number of reasons which it is unnecessary to discuss here, this test was better adapted for modification than the toughness test. The first modification consisted in breaking the sample into small blocks by means of a machine instead of by hand. A view of the machine used is shown in the accompanying figures. It consists of a 20-ton forcing press such as is used in automobile repair shops for forcing gears from shafts. The press is equipped with stationary and movable knife edges as shown, and is sufficiently powerful to break any standard 5-in. block. By the use of this machine the block may be broken into small cubes rapidly and much more accurately than is possible by hand. It possesses the additional advantage that there is no danger of fracturing the stone on any but the natural cleavage planes.

An abrasion test made upon fragments broken in the above manner will show a coefficient of wear of about 1.0 greater than when the old method is used. Much more concordant results are obtained, however, due to the ease of preparing check samples of similar size and shape. It will thus be seen that by the use of this machine one of the two objections to the standard Deval test may be overcome. On the other hand, the use of machine broken cubes, by cutting down the amount of wear, results in further narrowing the range in values obtained with the different granites. In order to increase this range, a modification of the abrasion test proposed by Scofield, Mattimore and others, was tried. This consists in running the test charge in an abrasion cylinder in which a number of longitudinal slots each 1/16 in. wide had been milled. The effect of the slotted cylinder was to increase the amount of wear by removing the dust cushion formed inside of the cylinder during the progress of the test. The effect of this cushion in cutting down the wear, although not as marked in granites as in some of the softer types, is still enough to cause a decrease of from 1.0 to 2.0 in the coefficient of wear. Comparative tests made on samples obtained from 12 representative granite block quarries are shown in the following table:

	Old standard method.		Machine broken fragments Slotted Clyinder.	
Ident. No.	Ave. Coeff. wear.	Max. variation.	Ave. Coeff. wear.	Max. variation.
1	11.4 (3)	0.7	9.2 (3)	0.2
2	11.8 (3)	0.7	9.9 (2)	0.2
3	9.1 (3)	0.8	6.5 (3)	0.4
4	10.5 (2)	0.8	9.7 (2)	0.2
5	11.1 (3)	1.3	9.5 (2)	0.6
6	8.4 (2)	1.9	6.9 (2)	0.5
7	9.1 (2)	1.7	6.9 (2)	0.4
8	10.1 (3)	2.5	8.2 (3)	0.6
9	9.3 (3)	1.3	7.0 (3)	0.6
10	11.7 (3)	0.7	10.5 (3)	0.5
11	8.6 (3)	1.1	6.7 (3)	0.2
12	9.3 (3)	2.1	7.4 (3)	0.2
Maximum	11.7	2.5	10.5	0.6
Minimum	8.4	0.7	6.5	0.2
Difference	3.3	...	4.0	...
Ave. variation	...	1.3	...	0.4

Figures in parentheses indicate number of samples tested.

Each of the 12 samples consisted of 6 standard block of uniform quality. Variations in the results in individual tests may therefore be assumed to be due to the method of conducting the test and not to any difference in the quality of the stone. The table shows the maximum variations in the results of two or more tests by each method on each of the 12 samples. It will be noted that much closer checks are obtained in every case by the use of the small machine-broken



Detail View—Showing Block in Place Between Knife Edges.

cubes. The average for the 12 samples is 1.3 by the old method as against 0.4 by the modified method. It is obvious, therefore, that the latter is much more reliable insofar as concordant results are concerned than the old standard method.

With the two exceptions referred to—that of breaking the sample by machine instead of by hand, and the use of a slotted instead of a solid cylinder—the proposed test is run in exactly the same manner as the old standard Deval abrasion test to which reference has already been made.

Interpretation of Results of Tests.—Having devised a method of testing which will give check results in the laboratory the next question to be considered is the proper interpretation of the results obtained so as to make them of practical value to the engineer. Opinions regarding the relative merits of different granites for paving purposes differ greatly. In general, however, experience has shown that granites which will show a coefficient of wear of 11 or more by the old standard method are satisfactory insofar as quality is concerned for use under the heaviest traffic to be encountered in and about the docks and railway terminals of our largest cities. Likewise, any granite which will show a coefficient of 9 or over will be suitable for general heavy traffic construction. These values have been used by the American Society for Municipal Improvements in their standard specifications for granite block paving for a number of years. In the recently proposed specification for block for granite block pavement of the American Society for Testing Materials coefficients of 11.0 and 8.0 were used. These values correspond to approximately 9 and 7 respectively when the modified test is used.

Reference to the table will show that when using the proposed test a limit of 7.0 for coefficient of wear will admit most of the commercial granites examined, the two exceptions being rather soft materials whose use under very heavy traffic has been open to question for some time. Practically all of the granites with which we have worked would pass the requirements of the two technical societies above mentioned. As has been pointed out, this table includes results typical of all the commercial granite block quarries in the East. The inference naturally follows, therefore, that judging by quality alone any of these materials should prove satisfactory for paving purposes. The writer believes that practical experience has substantiated this conclusion. In other words, it is perfectly possible to produce granite block from practically all of the established commercial quarries which will be of suitable quality for all ordinary paving purposes. It must be borne in mind, however, that in the tests above described only good, sound, fresh stock was used. This brings us to a consideration of the really important bearing which laboratory testing has on the selection of materials for use in the construction of granite block pavements. This is the certainty with which this test will detect unsound or disintegrated stone.

It has always been a disputed question as to just what constitutes disintegration. The theory that discoloration of the block was of necessity an indication of disintegration has been repeatedly disproved. Recent tests made by the Bureau of Public Roads have as a matter of fact shown that "sap" stone may in some cases be even stronger than the clear stock from the same quarry. On the other hand, it has been shown repeatedly in the laboratory that the abrasion test will indicate the presence of actually disintegrated material. Tests have shown that where disintegration has progressed far enough to render the block unfit for paving purposes the coefficient of wear will run as low as 5 by the old standard method and, of course, even lower by the proposed method. As everyone knows, unsound stone is sometimes shipped to the job from even the best regulated quarries. The distinct value of this test as a means of checking uniformity in the quality of individual shipments of black is obvious.

Field Tests of Granite Block.—In order to throw some light on the general questions involved in the foregoing discussion the Bureau of Public Roads recently began a series of tests to determine the amount and character of wear of small sections of granite block pavements when subjected to an accelerated test approximating the action of actual traffic. The nature and object of these have been fully described,† and mention is only made of them here to show the bearing which they have on the laboratory work just described. Briefly, it is hoped by means of these experiments to determine the influence exerted by such factors as the type of joint filler, the bedding course, and the foundation on the behavior of the block when subjected to an accelerated wear test. Each of the granites tested in the laboratory were used in the construction of these pavement sections, so that a direct comparison between the wear of the sections and the results of the abrasion tests will be possible.

Conclusions.—The following conclusions may be drawn from the work described above:

1. None of the laboratory tests which have been used for testing granite block may be depended upon to give even reasonable concordant results.

2. The abrasion test may be modified so as to give results which will check within 0.4, or 10 per cent of the range in coefficient of wear of granite block.

3. The maximum range in coefficient of wear by the modified method and including tests of good, fresh stock from practically all of the commercial quarries is from 6.5 to 10.5.

4. Discoloration of granite block is not necessarily an evidence of disintegration.

5. Disintegration which has progressed far enough to render the block unsuitable for paving purposes may be readily detected by means of the abrasion test.

Suggested Specifications.—In order to place the question of tests of granite block on a definite basis the writer would recommend that, in future, specifications for quality include one requirement only—that of coefficient of wear and that this value be determined by the above described abrasion test. The following specification is suggested:

NEW GRANITE PAVING BLOCK.

GENERAL. The paving block shall be of medium or fine-grained granite showing an even distribution of constituent materials of uniform quality, structure and texture.

PHYSICAL PROPERTIES. Block shall meet the following requirements:

Coefficient of wear, . . . not less than 7.0.*

The average of 3 determinations shall be used in reporting results.

METHOD OF TESTING. The coefficient of wear shall be determined in accordance with the standard test for abrasion of road materials of the American Society for Testing Materials (Serial Designation D-2. See Book of American Society for Testing Materials Standards, 1918), with the following exceptions:

1. The fragments composing the test charge shall be small cubes of such size that 50 pieces shall weigh within 10 grams of 5,000 grams. The cubes shall be prepared by splitting the block by pressure applied along the natural cleavage planes and not by sledging.†

2. The abrasion cylinder shall consist of the standard abrasion cylinder in which there have been milled a number of slots parallel to the axis of the cylinder, 10 in. long, 1/16 in. wide and 1½ in. apart.

DIMENSIONS. Block shall meet the following requirements:

Length on top .... 8 to 12 in.
Width on top .... 3½ to 4½ in.
Depth .... 4¾ to 5¼ in.

DRESSING. The blocks shall be so dressed that the faces will be approximately rectangular in shape and the ends and sides sufficiently smooth to permit the blocks to be laid with joints not exceeding ½ in. in width at the top and for a distance 1 in. down therefrom and not exceed 1 in. in width at any other part of the joint. The top surface of the block shall be so cut that there will be no depressions measuring more than ⅜ in. in depth from a straight edge laid in any direction on the top of said block and parallel to the general surface thereof.

Care shall be exercised in handling the blocks so that the edges and corners shall not be clipped or broken. Blocks otherwise acceptable may be rejected on account of spalling.

INSPECTION. Not less than three blocks, which shall be selected subsequent to delivery at the place of use by the engineer or his authorized representative so as to fairly represent the actual delivery, shall be tested for the coefficient of wear. No samples shall include blocks that would be rejected by visual examination. All deliveries shall be subject to further inspection at the point of use prior to and during paving. Blocks received at the work that are manufactured from a quarry other than the quarry or quarries stated in the certificate submitted by the contractor at the time of bidding shall be rejected.

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†See "Public Roads," Vol. II, No. 15, p. 28, July, 1919.

*In certain cases where exceptionally heavy traffic is expected, or other conditions warrant, a coefficient of 9.0 may be inserted.

†Sufficient pressure may be exerted to split a 5 in. block by the use of a 20-ton hand feed screw forcing press equipped with suitable knife edges.

In the above specification the requirements covered by the general, dimension, dressing and inspection clauses are identical with the recommendation made by the stone block committee of the American Society for Municipal Improvements at the last annual meeting of the society.

Development of Local Supplies of Road Building Materials

One of the problems confronting road builders is the obtaining of the necessary materials for the carrying out of the great construction program proposed for the present year. Heretofore it has been customary to rely to a great extent upon commercial plants for stone, sand and gravel. Existing commercial supplies, however, in many sections of the country, are far over figured, and it may not be possible for them to supply the greatly increased demand. Should this be the case it may be necessary for the contractors to produce the materials from local supplies. Useful information on the investigations preliminary to the development of a local supply was given by Mr. H. S. Mattimore, Engineer of Tests, of the Pennsylvania State Highway Department, in a paper presented Feb. 12, at the convention of American Road Builders' Association. An abstract of the paper follows:

In the development of local materials there are two stages, first the location and investigation by the state, second the development by the contractor. To succeed in this work one is just as necessary as the other.

For many years highway organizations have carried on systematic testing of materials but preliminary investigation and sampling of material sources has been done in sort of a haphazard manner. In most instances it has been placed as a secondary consideration, that is perhaps the survey corps, or some one who happened to be available at the time was sent to get a sample from a rock ledge or a sand bank. This resulted, as might be expected, in obtaining incomplete data which was not only misleading to the designing engineer, but also to the contractor bidding on the work. Sometimes a contractor investigated his own materials. The latter plan can hardly be considered a fair proposition. The contractor cannot afford to invest capital in an investigation without any assurity that he is to get the contract, also the time limit between the advertising and submitting of bids is not always sufficient to ascertain in the quality by test.

Material Investigations Should Be Made by State.—Material investigations should be considered with the planning and designing of a highway, and therefore should be done by the state itself. From an economic standpoint it is preferable to have one investigation than many separate ones by the various bidders. The part of the work carried on by the state, that is the investigation and sampling of local material sources is still in a primitive stage in many parts of the United States. It not only lacks organization, but many departments lack elementary knowledge on how the work should proceed.

In order to secure the full advantage of these investigations, first its importance must be realized. It requires an organization specializing to a large extent on material survey; this should at least be directed by an engineer familiar with materials and construction details.

A geologic map, if such is available, is of inestimable value as a guide in location work. If such is not available, a preliminary survey and investigation by a skilled geologist should be made. This is preliminary work only, and the final location work should be left to a trained highway engineer. The geologist can guide him regarding the positions of various rock strata and such a guidance will save much time and effort. As the next step when the engineer has familiarized himself with the general situation, a detailed investigation should be made from an engineering standpoint; that is considering the factors of availability, transportation to the job, situation as to water facilities, plant set up, uniformity of the rock strata, and any other factor that would effect an estimate.

All of this work regarding the practical situation of a quarry should not be left entirely to the contractor. If the state wishes to get full advantage of these locations, the deposit located must be examined from a practical standpoint. If this is not done, any information furnished to the contractor regarding local material sources will have little or no advantage. If the contractor is to bid with the idea of using such sources, he must have confidence in the location, and a degree of respect for the practicability of the engineer who investigated and estimated it.

The engineer employed on this work must have had sufficient highway experience to enable him to judge when deposits are practical to work and which are the most economic to use. After these deposits are located the most favorable ones are investigated in some detail so that the extent and quality of the material can be reported upon. Rock ledges are blasted out so that unweathered samples can be obtained and tested. This latter precaution is especially advisable in most limestone and sandstone deposits. If detached stones in fields or fences are available and considered the most economical for use, a fairly accurate estimate of their extent and location is taken so that hauls can be computed. The most difficult proposition in investigating field stone is the securing of a representative sample for test and estimating percentages of the different qualities available.

Information to Be Furnished Prospective Bidders.—Investigation of sand and gravel deposits is a difficult problem. Few, if any, sand and gravel deposits run uniform, and it often taxes the resources of the investigator to decide how practical it is to work the various deposits encountered. Some skill and experience is necessary to secure an approximately representative sample. Occasionally many test pits are required to determine the amount of material available.

The amount of time and expense necessary for investigation of individual projects is likely to vary with each project. If the situation is such that materials from commercial sources would be costly due to long hauls, etc., a greater expenditure of time and expense is justified in seeking for local materials, than when commercial supplies can be obtained at low cost.

Now the results of these investigations should be tabulated and information furnished to bidders with the proposal sheets, the information should contain the approximate location of the source given in distance from the station of the highway. The kind of material, that is whether sandstone, etc.—description of the source, whether open quarry or ledge, sand bank or pit, stream bed, etc.—the quality of the material and what classes or class of construction it is acceptable for.

The above information is absolutely essential, and additional information such as amount of stripping or waste might be given to advantage, also where sand alone is to be used from a supply it would be a good guide to the contractor to know the approximate per cent of gravel and sand as ascertained by test.

When the prospective bidder receives this material information he must not by any means feel that he is relieved from all responsibilities. The sole purpose of furnishing this information is a guide to inform him where suitable materials can be obtained. No state to my knowledge, has ever attempted to guarantee material supplies, and the contractor must realize this phase of it. An investigation by the state must be done with thoroughness, but it is expected that all bidders will examine these locations and decide for themselves regarding their practicability as a material source. In working such sources a contractor must follow a proper degree of co-operation. The improper working of stone ledges and sand banks can ruin the good material they do contain. Every quarry and sand bank should be thoroughly stripped before the face is worked.

Cost of Horse Maintenance at Boston, Mass.—The average cost in 1918 of maintaining the horses of the sewer and sanitary division of the Public Works Department of Boston, Mass., was $1.68 per day per horse, according to the recently issued annual report of the department. An average of 171.8 horses was kept. The itemized cost was as follows:

	Per horse per day.
Labor	$0.5837
Hay and grain	.8355
Fuel	.0087
Light	.0056
Rent and taxes	.0500
Yard and stable repairs	.0187
Yard and stable furnishings	.0285
Veterinary services and medicine	.0225
Horseshoeing, etc.	.1292
Total	$1.68

Relation of Highways to Motor Truck Operating Cost*

By ARTHUR H. BLANCHARD,
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Highways are merely the means to an end. That end is economic and efficient transportation of passengers and commodities. If this fundamental principle had been the universal basis for the improvement of highways, during the past 20 years, the problem of determining the relation of highways to motor truck operating cost would have been materially simplified. The highway transport engineer or manager cannot assume, for every transportation route, that what has been done is what should have been done. In fact, in the case of any one of thousands of proposed routes, he cannot assume that the highways is 100 per cent improved even based on the crudest ideas of what constitutes an improved highway. It is well to bear in mind that the construction of highways outside of municipalities is today in its infancy. Furthermore, it should be recognized that of the 2,500,000 miles of highways outside of municipalities in the United States, only 12 per cent can be classified as improved and that not over one-fourth of 1 per cent are suitable to carry intensive motor truck traffic.

No thorough consideration appears to have been given to the effect of highways on operating cost by many legislators and commissions when establishing schedules of legal rates for transportation of commodities. For example, the Nebraska uniform rate of 1½ ct. per 100 lb. per mile recognizes the fact that the roads of Nebraska will not permit a 300-day-a-year business with 5-ton trucks, but entirely fails to recognize the fundamental fact that a 30-mile haul on one route may easily cost twice as much as on another route, particularly as only about 2 per cent of Nebraska's rural routes are classified as improved.

Thorough Field Investigation of Transport Routes Necessary.—It is evident that a thorough field investigation of every proposed highway transport route should be made and that the results of this survey should be an important factor in the final decision pertaining to the establishment of a highway transport business. The result of this survey, from the standpoint of highways, may be roughly classified under the following three heads: first, relation of unimproved highways to operating cost; second, relation of proposed new construction and the reconstruction of improved sections to operating cost; and third, relation of sections of improved highways which will not be reconstructed for a period of less than 5 years to operating cost.

The first class of sections of a proposed route, namely, the unimproved portions of highways, may present conditions of narrow widths of roadways, steep grades, short turns or rocky, sandy or clayey surfaces, such that a glance will be sufficient to condemn the route for efficient highway transport.

Effect of Poor Highways on Truck Operating Costs.—Generally speaking, unimproved highways constitute a positive economic barrier to the development of a highway transportation business. Take for example George H. Pride's 1919 average daily cost of $28.56 covering the operation of a 5-ton truck for an average of 50 miles per day for 300 days per year. These figures are based on New York City conditions including the average type of improved highways outside of cities over which his trucks operate. Let us diagnose Mr. Pride's cost sheet and determine what would be the effect of substituting a system of poor roads for the system of improved roads in the near vicinity of New York City. It is self evident that poor roads would materially raise the cost of at least the following items on the cost sheet: tires; oil, grease, etc.; gasoline; depreciation; maintenance, and lost time period. A combination of a rough roadway on steep grades for a mile section of a 25-mile route might easily double or treble the operating cost if not actually rendering continuous operation of a truck over such a route impracticable.

Saving in Gasoline Due to Improved Roads.—The following interesting deduction pertaining to saving in gasoline which will result when the system of 5,000 miles of highways in Illinois are improved has been made by A. N. Johnson. He assumes that these highways will develop a traffic of 500 motor vehicles per day for 300 days in the year. He estimates that the saving of gasoline by the above traffic on improved roads as compared with earth roads would be 66,000,000 gal. per year or approximately $15,000,000. The results of tests carried out by the White Co. of Cleveland with a 2-ton motor truck are of interest as an indication of the saving of gasoline due to operation of motor trucks on some of the types of pavements suitable for trunk highways as compared with operation over earth roads. The investigations showed that on concrete and brick pavements it was practicable to operate a loaded 2-ton motor truck for an average of 11.5 miles on 1 gal. of gasoline, whereas on the average earth road only 5.8 miles to the gallon was obtainable. In round figures, the conclusion drawn from the test was that it was possible to operate the 2-ton truck on highclass pavements for twice the distance which was practicable on earth roads.

Effect of Detours During Road Construction.—The second classification of highway sections cover those parts of routes which are liable to be constructed or reconstructed within a comparatively short period after the establishment of a transportation business. This phase of highway improvement demands serious consideration as construction and reconstruction generally implies that vehicular traffic will be shunted onto detours, most of which are far from satisfactory, considered from the standpoint of economic highway transport. The growth of motor transport will force highway engineers to give serious attention to providing serviceable roadways for traffic during highway improvement. In some cases roadways are provided alongside the highway under improvement, in others one-half of the highways is improved at a time and in others the traffic uses detours. Highway transportation interests will soon emphatically demand that the same consideration be given to the facilitation of highway transport as is usually provided for railway transport when a railroad line is under reconstruction.

In connection with the third general class of highway sections of a given route, that is, improved sections which will not be reconstructed in the near future, it is necessary to consider the influence of each fundamental element of a highway upon economic highway transport.

Drainage and Foundations.—The writer believes that the increasing use of highways by motor transport will cause so many failures of insufficiently drained highways and others which have weak foundations that there will be a general improvement in the near future. As loads are transmitted from the wearing course to the foundations and from there distributed to the subgrade, the bearing power of the soil composing the subgrade is an important factor in the design of the highway. It is well known that the bearing power of soils in many instances is materially increased by efficient drainage. The roadway, therefore, should be so drained that the maximum bearing power of the subgrade is developed. While a poorly drained roadway might support a light rural traffic, it will be rapidly destroyed if subjected to commercial motor transport including, for example, several 5-ton trucks.

The highway transport engineer or manager can neither assume that drainage systems and foundations have been scientifically designed nor that these important elements of a highway have been constructed in accordance with practice based on service tests. Highway transport literature contains many references to cases where motor trucks have become mired in poorly drained roadways or have broken through wearing courses supported by weak foundations. When the transport survey is made, care should be taken to determine, by inquiries along the route, the ability of the roadway to carry heavy loads during the spring especially. It is well to keep constantly in mind that an ideal roadway surface is not necessarily an indication that the drainage system and foundations are suitable for motor truck traffic. Poor drainage and weak foundations on a section of a transportation route may readily wreck a highway transport business or at least require the charging of higher rates to cover increased cost of operation.

Grades.—Only general deductions may be made pertaining to requirements relative to grades for motor transport. Unfortunately little data are at hand covering the relative efficiency of truck transportation over various grades on different types of roadway surfaces. Of course, the general deduction may be made that the cost of haulage varies directly with an increase in grade and that the tonnage which can be economically hauled varies inversely with an increase in grade. In all probability the present fundamentals of grade design will not be modified until sufficient data have been accumulated to demonstrate that present practices are uneconomical either from the standpoint of motor transport or the maintenance of the roadway. The cost items relative to tires, grease, oil, gasoline, and lost time period, and probable depreciation and maintenance will be increased by material grades on transport routes. General allowance can be made but close estimates are impracticable unless the transport engineer has had experience with exactly the same conditions which he encounters on a new route.

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*From a paper presented Jan. 29 at the Annual Convention of the National Highway Traffic Association.

Widths of Roadway and Shoulders.—Roadways economically designed must provide for carrying the traffic on the paved roadway surface and not rely upon earth shoulders to carry a part of the traffic or serve as turnouts. It has been demonstrated that the latter practice is not economical from the standpoint of the maintenance of the pavement or shoulders nor is it efficient or safe from the standpoint of traffic using the highway. In order that a two traffic line highway should be satisfactory for all classes of vehicular traffic, it will be necessary to follow English interurban traffic practice which requires that slow moving, or in this case commercial traffic, shall keep to the side of the roadway. It is, however obvious that a heavy motor truck operator will insist upon allowing a certain amount of leeway between the outside wheels of the truck and the edge of the roadway, as many operators have had unfortunate experiences with motor trucks being stalled in soft shoulders or ditched.

From observations of commercial traffic made on many highways outside of municipalities, it is the writer's conclusion that it will be necessary to allow at least 1 ft. clearance between the body of the truck and the edge of the paved roadway. Furthermore, these observations indicate that motor truck drivers, traveling at speeds from 10 to 15 miles an hour, will endeavor to maintain a clearance of 2 ft. between passing vehicles. A compilation of the maximum width of 8 ft. for each of two trucks and the clearness suggested indicates that a minimum of 20 ft. for two lines of traffic is a conservative recommendation.

It should be observed that the country highways of England and the national routes of France have been constructed for many years with roadways having widths of not less than 20 ft. If the transportation survey indicates that the amount of traffic will require provision for more than two lines of vehicles, a greater width than 20 ft. should be adopted, the additional width depending upon the character of the traffic. It does not require much imagination to reach the conclusion that many interurban highways will be subjected, during the next decade, to traffic which will necessitate roadways sufficiently wide to accomodate at least two lines of motor trucks and two lines of passenger cars.

Highway transport investigators will do well to give careful thought to widths of roadways on a proposed route. On a narrow roadway, say from 9 to 14 ft., there will be, in many cases, continual danger of running on to earth shoulders with resultant serious loss of time if the truck should become stuck in soft material. Furtherfore, a given width of roadway is able to carry a certain maximum traffic. As this limiting amount of traffic is approached or exceeded, there will be serious loss of time due to congestion of vehicles. The cost item of lost time, therefore, may be materially increased due to narrow and inadequate roadways existing on a given transport route.

Curves.—Motor vehicle traffic has effected a decided improvement in the design of highway curves especially in the direction of the easing of sharp curves, provisions for clear sight around curves and the banking of roadways. The importance of these details will be accentuated by the development of motor truck traffic. Many routes have so many sharp turns, that this element of highways may effect economic transport through lost time in negotiating such turns, increased wear of tires, and possible depreciation and maintenance due to collisions or other accidents.

Roadway Wearing Courses.—The forces due to motor truck traffic, which should be given consideration in the selection of a roadway wearing course are the direct load causing compression in the wearing surface, impact forces, and shearing forces of the driving wheels, the amount of which will be a function of the weight of the vehicle and the speed at which it travels. If all of these forces have not been given proper consideration, the wearing course will wear rapidly or will disintegrate. The wearing course is of particular interest to motor truck users because of the variations in resistence to traction on different types of roadway surfaces. Statistics are meagre relative to traction, especially as concerns motor trucks. Investigatons made to date are merely a drop in the bucket as compared with the amount of research which should be undertaken in order to have available reliable data. At the present time, only the most general conclusions can be drawn as was the case with the tests carried on by the White Co., cited above.

Highway transport interests should give careful consideration to the effect on motor trucks due to travel on different types of roadway wearing courses. The mistake is too often made of considering wearing courses in their ideal state or during the first six months after completion. All types wear under traffic and hence the character of the surface of a roadway after 2 to 5 years' life is generally more important than its condition upon completion of an improvement. Not only is resistence to traffic increased as the surface becomes worn but furthermore, the effect on the motor truck through impact forces caused by travel on rigid monolithic pavements will result in a material advance in depreciation and maintenance charges.

Bridges.—A bridge is an integral part of a highway. It is to be regretted that this fact usually has not been recognized by lawmakers. Many highways are built of sufficient strength to carry the motor traffic to which they are subjected while the bridges are so weak that their condition prevents the use of the highway by a part of the motor truck traffic. Many citations may be given of highways which have had to be abandoned as commercial transportation routes due solely to the weak conditions of the bridges. One reason for this condition is that many state laws provide for the construction and maintenance of roadways by the state, while the bridges are under the jurisdiction of counties or towns. It is self-evident that bridges of trunk highways connecting municipalities should be designed for loads of not less than 30,000 lb. and it would appear advisable, considering the character of the structure, to follow the practice of the Pennsylvania State Highway Department and design highway bridges for loads of 40,000 lb. The clear width of the roadway of a bridge should comply with the requirements pertaining to roadway width cited above. In addition, the vertical clearance should be given consideration and in this connection the overall height of 12 ft. 2 in. for motor trucks heretofore mentioned should receive attention. This is an important factor, not only in the design of through truss bridges but likewise in providing for clearance underneath railway bridges.

Highway transport companies should thoroughly investigate permissible loads, clearances, roadway widths of highway bridges on transportation routes. Many instances have come to the attention of the writer where bridge load limits of 2 or 3 tons have occurred on highways whose surfaces are capable of carrying 5-ton motor truck traffic.

Conclusion.—The foregoing discussion indicates that the probable cost of transport over highways outside of municipalities is not susceptible of an exact mathematical analysis. Although this situation is far from satisfactory, it does not mean that highway transport should not be based on as definite analysis as our present fund of information and experience warrants. The interrelationship between highways and the cost of highway transport is so interwoven and complex that many highway transport managers have literally thrown up their hands and simply taken a chance upon the results to be secured from organizing transportation companies. Based on the meager investigations made to date, taken in combination with the combined experience of English and American highway transport authorities and highway engineers, it is evident that certain general conclusions may be drawn as a result of a careful highway transport survey for any proposed transportation business. A consideration of these deductions will usually warrant the installation of a highway transport business or the positive rejection of the proposition. This is particularly true when it is considered that the installation of highway transport in a given community should not be based on a narrow margin of profit. There are too many uncertain factors, such as competition with other transport companies and common carriers by rail and water, state regulations pertaining to weights, dimensions and speeds of motor trucks, legislation pertaining to licenses, franchises and rates, snow removal practice, and variations in the volume of business, to justify a highway transport engineer or manager figuring profits and losses from a business standpoint in thousands of dollars and the variations in operating cost due to the several highway factors in thousandths of a cent.

Pavement Design at Street Crossings

Considerable study has been given by the Board of Local Improvements of Chicago to securing comfort and safety for pedestrian traffic at street, alley and private driveway crossings.

The practice followed was outlined by Mr. H. J. Fixmer, Paving Engineer of the Board, in a paper presented at the recent annual meeting of the Illinois Engineers Society. The matter following is taken from the paper:

On certain streets the usual step from the abutting sidewalk to the pavement surface has been eliminated at all alley, private driveway and street crossings in residence districts. On business, or through traffic streets, considerations of safety and the greater importance of vehicle traffic modify the general plan. On all street, alley and driveway crossings along such a street the pavement is built even with the sidewalk for a distance of at least 6 ft. nearest the building line. A step of from 5 to 7 in. is made at the curb adjoining the crosswalk crossing the busy street. By eliminating the steps along the street the maximum pedestrian traffic is accommodated with little interference with the comfort and safety of the slow moving cross vehicle traffic. The step at the cross walk crossing the business street permits the pavement surface to be carried through on a nearby level grade, which accommodates the maximum vehicle traffic. The presence of the step tends to cause the pedestrian to hesitate (and look) before crossing the busy street.

Where the street is of unusual width or carries a great volume of fast moving traffic a safety island is often built. The island is usually 4 ft. wide and 6 in. above the pavement surface.

Where two car-line streets intersect the usual step at the crosswalk is eliminated, since all vehicle traffic must slow down in crossing, and because the large pedestrian traffic at this location demands a comfortable crossing. Where a vehicle is traveling less than 15 miles per hour the slight raise in the pavement surface occasioned by the so-called "flush crosswalks" causes no inconvenience or noticeable jar.

The matter of smooth surface at street crossings was early recognized. In the old granite block pavement crossing slabs were laid. In the old macadam pavement brick crosswalks were built. In the typical village or small town the first street improvement generally consists in building a plank, stone or concrete crosswalk. Time has proved them very undesirable as they soon become uncomfortable and even dangerous to vehicle traffic. Since modern vehicle traffic requires a smooth surface it is found that a modern pavement agreeable to such traffic is satisfactory to foot traffic.

The crossing should be as level as is consistent with the contour of the pavement and with surface drainage. This means a fairly flat crown.

The crossing should be clean and dry. By reason of paving the crossing even with the sidewalk, with a low crown and slightly increasing the slope of the gutter away from the crossing, the crossing keeps clean and dry automatically Where a step is necessary it is a refinement worth while to increase the gutter slope across the crosswalk to enable the gutter water to pass without depositing any refuse at the crossing.

Salaried Road Commission for New Jersey.—In his annual address to the state legislature Governor Edwards of New Jersey recommended that the present state highway commission of eight unsalaried members be abolished, and a commission of three members selected, who should receive adequate compensation.

An Apparatus for Determining the Consistency of Concrete

By F. L. ROMAN,
Testing Engineer, Illinois State Highway Department.

Experiments were undertaken in the spring of 1919 in an effort to obtain an apparatus which would give fairly concordant results, and which could be used in the field for determining the consistency of concrete. It is well known that an excess of water is injurious to concrete and may cause a considerable decrease in its strength, a "sloppy" mixture giving concrete having a strength of only from 25 to 50 per cent of the strength of the so-called "dry" concretes. Attempts were made to regulate the consistency of the concrete used in state highway work in Illinois, first by specifying that a conical pile of the concrete having a 45° slope should neither flatten nor run at the edges, and later by specifying that a 6x12 cylinder of the concrete should show a "slump" or vertical settlement not exceeding certain limits. This second method of measuring the consistency of the concrete had been used by Prof. D. A. Abrams in some experimental work at Lewis Institute, a mechanical appliance being used to remove the mold vertically. When attempts were made by the writer to determine the consistency of concrete in the field by means of a cylinder in which the concrete had been tamped and subsequent removal by hand of the mold as nearly vertically as possible, very erratic results were obtained. It was found that with the same concrete it was possible, for example, to obtain "slumps" ranging from 1 in. to 6 in. When the mold was removed very slowly and with extreme care from a concrete of medium consistency, the concrete cylinder would remain standing and show a small slump. When the mold was removed quickly from the same concrete, the cylinder would usually crumble or "tip over" and show a high slump.

It seemed apparent, however, that the erratic results observed could be eliminated by the use of a truncated cone of suitable design. The truncated cone desired was to be such that it would register fairly uniformly changes in the amount of water in the concrete. The height and slope of the sides were to be large enough that only "dry" concrete would be without slump, but on the other hand the height and slope should not be so large that the concrete cone would tend to tip over or that the slump registered would depend to any appreciable extent on the speed at which the mold was removed. Several forms of truncated cones of various sizes and made of heavy galvanized iron were prepared, care being taken that the forms were perfectly smooth and circular through their entire depth. These forms were used in comparison to determine their efficiency.

In experiments I and II, three truncated cones of various sizes and a 6-in. diameter by 12-in. high cylinder were used. For convenience these truncated cones were numbered as follows: No. 1, 12 in. high, 8 in. diameter at base and 4 in. di-

TABLE I—GRAVEL CONCRETE (1:2:3½ MIXTURE).

Ratio of water to cement.	Slump in inches of cylinder.	Slump in inches of Truncated Cone No. 1	Slump in inches of Truncated Cone No. 2.	Slump in inches of Truncated Cone No. 3.
0.75	0	¼	0	0
0.80	½	½+	¾	½—
0.85	1½	2	1½	1+
0.90	6	4	2	1½
0.95	6¾	6	3	3½
1.00	7¼	7¾	5½	4½
1.05	9	8½	6½	5
1.10	9	8¾	5	5

Note.—Gravel graded from 2 in. to ¼ in., 50 per cent passing 1 in. screen. Sand graded ¼ in. down, 50 per cent passing 20 mesh sieve.

TABLE II—CRUSHED STONE CONCRETE (1:2:3½ MIXTURE).

Ratio of water to cement.	Slump in inches of cylinder.	Slump in inches of Truncated Cone No. 1	Slump in inches of Truncated Cone No. 2.	Slump in inches of Truncated Cone No. 3.
0.75	0	¼	0	0
0.80	0	½	0	0
0.85	¼	½	0	0
0.90	¼	1	½	½
0.95	½	1¼	½+	½
1.00	½	2	1	1
1.05	1½	3	2	2
1.10	4½	4	2	2
1.15	6	5	3	2½
1.20	7	6	4	4
1.25	7	7	4½	4

Note.—Crushed stone graded from 2 in. to ¼ in., 50 per cent passing 1 in. screen. Sand graded ¼ in. down, 50 per cent passing 20 mesh sieve.

ameter at top; No. 2, 10 in. high, 8 in. diameter at base and 5 in. diameter at top; No. 3, 10 in. high, 10 in. diameter at base and 5 in. diameter at top.

Tables I and II show that up to very sloppy consistencies the three truncated cones give much more consistent results than the cylinder. A large portion of these tests were repeated several times at each consistency, and it was noted that cones No. 1 and 3 gave the most uniform results. The check results at any given consistency with truncated cone No. 1 were in nearly every case within ½ in. of the original results given in Tables I and II.

On the assumption that differences in the consistencies of dry mixtures might be further emphasized by means of tests with taller truncated cones, Experiments III and IV were undertaken. Two tall truncated cones numbered 4 and 5 were used in comparison with No. 1. Truncated cone No. 4 was 16 in. high, 12 in. in diameter at the base and 4 in. in diameter at the top, while truncated cone No. 5 was 15 in. high, 10 in. in diameter at the base and 4 in. in diameter at the top. The results given in Tables III and IV indicate that the truncated cones No. 4 and 5 show slightly better than truncated cone No. 1 the variations in the consistencies of dry concretes. It was noted, however, that the tall truncated cones No. 4 and 5 gave somewhat erratic results, the tendency of the molded specimen being to settle on one side. For example, with a water ratio of 0.90, the mixture used in Experiment III gave with truncated cone No. 1 results varying from 1½ to 2 in., with truncated cone No. 4. results varying from 2 to 3½ in. and with truncated cone No. 5, results varying from 1½ to 3 in. Five check tests were made in each case.

As a whole truncated cone No. 1 appeared to be superior to all other truncated cones investigated, and was far better than a cylinder for determining the consistency of concrete by means of a "slump" test. This truncated cone measured satisfactorily differences in consistencies of the concrete mixtures commonly used, and when tested out in practical work the past summer, it was found to give excellent results. This form of apparatus was, therefore, adopted for determining the consistency of concrete used in state highway work in Illinois.

As stated this truncated cone form or mold is 12 in. in height, 8 in. inside diameter at the base and 4 in. inside diameter at the top. The apparatus used by this department are of 24 gauge galvanized iron and were manufactured locally at a cost of about $2.50 each. For convenience these molds were provided with handles and foot holds. The handles are about 3 in. wide, riveted on each side about 5 in. from the top of the apparatus, and consist of strip metal about ½ in. wide. The foot holds are made of similar strips, riveted near the bottom of the apparatus and extending out 2 in., slightly above the level of the bottom. The top and bottom of the apparatus are turned on ½ in. wire and special care has been taken that the truncated cone is circular and perfectly smooth throughout its entire depth.

When making a slump test the base of the truncated cone mold is placed on a flat horizontal surface. This mold is filled with the concrete, care being taken to tamp or rather arrange the mixture in the apparatus to obtain dense concrete and avoid stone pockets, as large voids or stone pockets tend to cause the concrete specimen to slump on one side rather than vertically. The mold is removed as nearly vertically as possible and the "slump" or vertical settlement (height of molded specimen minus height of concrete after settlement) is determined. Usually the concrete settles and comes to rest almost as quickly as the mold is removed, but it is advisable to take all readings about one minute after the mold is removed.

TABLE III—GRAVEL CONCRETE (1:2:3½ MIXTURE).

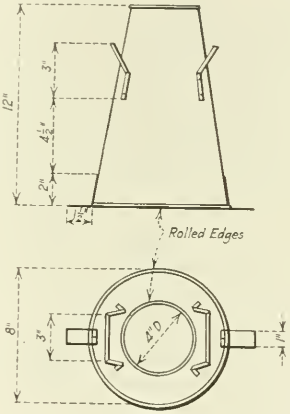
Ratio of water to cement.	Slump in inches of Truncated Cone No. 1.	Slump in inches of Truncated Cone No. 4.	Slump in inches of Truncated Cone No. 5.
0.75	0	0	0
0.80	½	½	½
0.85	1	1	1
0.90	2	2½	2½
0.95	5	6	7
1.00	6	9	8
1.05	7	9½	9

TABLE IV—CRUSHED STONE CONCRETE (1:2:3½ MIXTURE).

Ratio of water to cement.	Slump in inches of Truncated Cone No. 1.	Slump in inches of Truncated Cone No. 4.	Slump in inches of Truncated Cone No. 5.
0.65	0	0	0
0.70	½	½	1
0.75	1½	2½	5
0.80	4+	6	7
0.85	5+	-	7½
0.90	7	7	9½

Experience in determining the consistency of concrete with the truncated cone apparatus would indicate the following "slumps": Very dry consistency, no "slump"; fairly dry consistency, ½ to 1 in.; medium to wet consistencies, 1 to 4 in.; wet to sloppy consistencies, 4 to 8 in.; very sloppy consistencies, above 8 in. It should be noted, however, that crushed stone concrete will show somewhat less slump than gravel concrete of the same consistency due to the fact that angular fragments will to some extent be held in place mechanically and will not rearrange themselves as readily as the round pebbles. The difference in slump due to different aggregates is least apparent at the drier consistencies, and for future state highway work in Illinois one general requirement only is made, that all concrete for pavements shall have a slump of ½ to 1 in.

It may be well to point out at this time that the consistency of concrete cannot be regulated by means of the ratio of water to cement. While it is true that with the same mixture and exactly the same materials used under identical conditions, the consistency and hence the strength of the concrete are regulated by the ratio of water to cement, yet it is very seldom that these conditions will hold true for any length of time in practical work. With materials from the same source there are usually small variations as to size and moisture content and with materials from different sources the same mixture and same amount of water may give concretes of entirely different consistencies. This is well illustrated by Experiments I and III in which different gravels were used, the mix being, however, the same in all other respects and the gradation of the gravels being also practically identical. With a ratio of water to cement 0.90, for example, the mixture used in Experiment I gave a slump with truncated cone No. I of 4 in., while the mixture used in Experiment III gave a corresponding slump of 2 in. In Experiments II and IV with crushed stone the same proportions of materials were used for the mixtures, but entirely different fine and coarse aggregates as well as different cements were used. Again it can be noted that for the same ratio of water to cement different consistencies were obtained. Therefore, the consistency of concrete cannot be regulated by specifying the amount of water to be used for each batch, but a visual inspection of the concrete based upon frequent checks with a slump apparatus such as has been described will give far better results.



Truncated Cone No. 1 for Slump Tests of Concrete.

Pennsylvania Highway Department Uses 2,648 Men in Snow Removal.—During the week ending Feb. 7, the maintenance division of the Pennsylvania State Highway Department employed 345 foremen and 2,303 men in removing from the highways the heavy snowfall of Feb. 4. The department had in use 35 automobile trucks on which snow plows were mounted. It also used 243 horse-drawn road machines. The same number of teams and wagons were in use, or a total of 521 vehicles.

Recent Developments in Brick Paving Practice*

By M. B. GREENOUGH.
Secretary National Paving Brick Manufacturers' Association.

Review of Past Experiences.—Nearly all brick pavements laid before 1895 were filled in the joints with sand or bituminous material. For many years they were laid upon natural foundations. Comparatively slight attention was paid to variable conditions of sub-soil drainage and other factors in soils measuring their supporting power. Artificial bases had their inception in the belief that thus might imperfectly drained or consolidated subgrades be bridged over and settlements in weak spots prevented. The cushion or bedding beneath the brick primarily was intended to compensate for unevenness in the surface of the base. Sand and bituminous fillers continued to be used after the construction of artificial bases became general and after functions without number in addition to these mentioned had been ascribed to artificial bases.

With fillers of these kinds, chief reliance for the durability of the pavement as a whole was placed in the wearing qualities of the individual service-unit. That confidence was not misplaced is proved by the very large numbers of these old brick pavements in all parts of the country that are now in service, many of them laid long before 1895.

At the time of which we are speaking, there had not been developed a bituminous filler that could meet the much specified requirement that "it shall not flow in hot weather nor become brittle in cold weather." The result was that as soon as the filler had left the joints the edges of the brick cobbled. Pavements then became noisy, naturally enough, when traversed by iron-tired vehicles. Nor could the open joints be justified in view of the increasing demand for clean streets.

The development of cement-grout-filled brick pavements grew out of these conditions. The hard filler, it was thought, would protect the edges of the brick. Cobbling under traffic would be prevented and at the same time a surface promoting maximum sanitation would be provided.

Moreover, it was believed that the firm bonding of each brick to its neighbor would furnish a monolithic wearing surface reflecting all the inherent service-value of the individual brick composing it.

Just as the sand cushion had been used with sand and bituminous fillers, it was continued in use with cement grout, purely on the basis of precedent.

Many millions of square yards of brick pavement cement-grout filled on the sand cushion were built in the period from 1895 to 1915. This type came to be regarded as the all but universal type in the East, the South and throughout Ohio, Indiana and Illinois. Of the West we shall speak later. But east of the Mississippi River this type of brick pavement almost became the single standard.

It became increasingly apparent, however, in observing this type in service, as built under average working conditions, that the sand cushion was a tricky and dangerous element of the structure. Uniform compression was the exception rather than the rule. In all too many cases, patches of the surface were broken down. The brick themselves have given the appearance of being crushed under traffic. But it was soon discovered that the real cause was in an imperfectly compacted sand cushion. The sand would be forced into the joints from below when the surface was rolled. The filler would enter the joints (in many cases) only a fraction of an inch. A force was therefore exerted upon only a fraction of the face of the brick, sufficiently concentrated in many instances to snap off entire tops of brick.

The sand cushion and grout-filled type, possible to be built satisfactorily through care and watchful supervision, was finally found inadvisable of further use. The hazard was too great. It was satisfactory neither to the public, to engineers nor to the paving brick industry.

Green Concrete Foundations And Semi-Monolithic Type.—The solution seemed to be found in the development in 1914 of the green concrete foundation type and the semi-monolithic type of brick pavement. If you will consult the literature of the period from 1914 to 1916 you will find the constantly reiterated belief that the principal merit of the two types lay in the elimination of the hazard of the sand cushion. That belief has been justified in the facts. It has also been proved, as it was predicted at that time, that while longitudinal cracking, common to the sand cushion type in frost latitudes, while not altogether eliminated, has been reduced.

There can be no question as to the improvement effected in cement grout filled brick pavements by supplanting the plain sand cushion with a mixture of cement and sand or by laying the brick in the green concrete. But on the other hand, it is only fair to point out that, from the time cement filler was introduced, we have had to deal with the problem of the paving slab. A condition of unsatisfactory joint filler was sought to be solved. Unquestionably the remedy gave the desired edge protection to the brick but it likewise introduced hazards of its own for the relief of which we must await a more definite and complete knowledge of slab pavement stresses and strains.

The history of brick paving has been one of a continual seeking for a filler that will furnish the required edge protection to the brick so as to form a smooth and sanitary surface and at the same time to cause the pavement surface as a whole to bring to a maximum extent wearing resisting properties of the single unit.

A Filler Developed.—So far the discussion has largely covered that section of the country lying east of the Mississippi River. What of the West?

In its early improvements it somewhat naturally followed the practice of the East. Being in the field of asphaltic oil production on a large scale, it naturally turned to asphalt filler as the principal one. On account of its being a native product it is natural that an effort should be made to improve it for its several uses, filler among the rest. For many years there was no special ground for thinking that extraordinary progress was being made. But where the East turned from bituminous to cement grout filler, the west persevered in attempting to improve its asphalt filler.

Fillers produced showed increasing stability under high temperatures and less brittleness under low. And since 1912 an asphaltic filler has been generally used in brick pavement construction that does meet the situation. The second outstanding development in brick paving practice in 1919 has been the rapid growth in the amount of this filler used in all parts of the country and in the yardage projected for future construction.

The Standard Brick.—Third among the developments of the year now past has been the increase in the use and specification of what is being styled the standard brick, namely, the 3 by 4 by 8½ in. plain wire-cut brick. Already well-established throughout the West, its use has spread during the year to points east through Illinois, Indiana and Ohio and with respect to the absence of lugs, Pennsylvania, and in the South.

Prior to 1895 nearly all brick laid measured 2¼ by 4 by 8 to 9 in. They were plain wire-cut and unrepressed. They were thoroughly well vitrified brick; so much so that they were sometimes somewhat irregular in shape. But they did possess beyond question unequalled wearing qualities. They were very tough and very hard. It was at about this time that agitation began among engineers for a brick of more perfect shape. The response of the paving brick industry was the brick of the so-called block size 3½ x 4 x 8½ in.

Coincidentally with the making of the block size came the addition of projections or lugs for spacing. The plain wire-cut brick had done their own spacing. With the extreme regularity that was expected with repressed brick, the lugs were deemed necessary. With perhaps equal weight the argument for foothold for animals was advanced as an additional reason. The fact that cement grout filler had come into use did not have a great deal of influence as far as lugs were concerned until engineers began to use the coarse grades of sand in the grout. It is also true the rounded edge of repressed brick assisted rather than otherwise, the entrance of sand cushion into the joints from below.

Older engineers who were laying brick at this time will confirm the fact that cement grout filler was used with the plain wire-cut brick without difficulty. There are too many of these old streets still in use in this very section of the country to speak other than in the affirmative on this point.

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*From a paper presented Feb. 10 at the convention of the American Road Builders' Association.

Once the block size of brick began to be made by all manufacturers, there was practically no change in the size or shape of brick until 1910 there was developed west of the river wire-cut brick 3 x 4 x 3½ in. in size, having two instead of four lugs formed by the die instead of being repressed.

Also there were produced east of the river contemporaneously wire-cut-lug brick that aimed to recognize the demand for the advantages of wire-cut as against repressed brick. In size no change was made from that of the repressed brick. Edges of this and the wire-cut brick west of the river were square, whereas, repressed brick were round-edged.

The wire-cut brick seems thoroughly to be established as to preference among engineers for all brick construction. And with the passing of the repressed brick, seems also to have passed the height of the demand for lugs. They were dropped from the brick previously mentioned as having them formed by the die more than two years ago. And in the 3 by 4 by 8½ size they are being increasingly regarded by engineers as superfluous.

Modern Conditions. No longer can it be said that there is a universal type of brick or other pavement. Let us analyze this statement and see if it is tenable.

Engineers are saying "Do we use standard footings for all columns in high building construction? Do we use standard designs for every bridge pier; for all dams; for each retaining wall?"

The answer of course is "no." Yet these are comparable departments of engineering. Each of these structures is called upon to support loads and each rests upon whatever soil foundation is available in each case. We must bear in mind also that each of these is a localized structure with a minimum expectation of variation in subsoil beneath it. Yet we very well know that sub and also surface soils vary noticeably within short distances.

In spite of the precedent for individual designing thus established for structures resting upon the earth, it has been ignored to a great extent in road construction. Engineers have not insisted that subsoil and surface drainage should be made as perfect as possible.

Drainage has been neglected to the point of being ignored. Coupled with the known fact that soils vary within short distances and that saturated subsoils afford little if any bearing value for the pavement structure, we have required the construction of "Standard" types of pavement without regard to these conditions. It is not unusual that the same kind and depth of base will be specified for a road 12 miles long. If the section is adequate for the worst condition then it is extravagantly designed for every other condition.

Extravagance is not compatible with sound engineering. Because in one locality a brick pavement for example has been built on a 4 in. concrete base is not justification universally for that depth. Conversely it does not follow that because a 6 in. base seems to be needed in one place that the same depth is required a mile away.

The time is coming, and it is not far distant, when a single stretch of pavement will be designed in short sections. In a given contract for a single road there may be concrete base, rolled stone, gravel or slag base; each one may be anywhere from 4 in. upward in depth. And if we carry the thought to its logical conclusion, there may be portions requiring no artificial base.

Individually designed roads are a necessity. The use of blanket types is wasteful. It ignores the fundamental principles upon which the character of the profession's public service is founded. It cannot endure.

As nearly correct a description of a slab pavement as we can now write is this: It is a continuous slab resting upon a continuous support of varying elasticity, to be designed to carry moving loads. As yet we do not have a proved analysis of such a structure. The nearest approach to it will be found in the analysis of rail stresses and as far as this work has proceeded it is based upon results secured by the use of an extensometer under actual service conditions.

It will also be recalled that the simple beam theory is based upon positive bending moments. There are no negative moments in a simple beam. When beam or slab continuity is introduced however, you have set up a consideration of negative moments. Under moving loads a negative moment moves in advance and in rear of the load and is effective in the vicinity of the support. Witness the analysis of continuous beams on fixed supports. Just what happens on elastic supports is yet to be shown.

Admittedly this discussion is theoretical. Fortunately we have recent data presented by the office of public roads derived from the measurement of the effect of motor trucks upon pavement surfaces to show that the principal force of traffic to be met is impact and not bending.

What can we do while awaiting the production of scientifically determined data that can be used with the backing of proof? The answer to that question is clear. We should return to first principles. We should place ourselves upon the safe ground of minimum hazard.

In the end that means a much more discriminating use of cement grout filler as far as brick pavements are concerned. It means that in many cases concrete bases will be supplanted by another type—the rolled base. It means the passing of standard cross-sections of pavements of all types. And these things mean laying the foundation of real economy pavement design.

The coming of a saner period of pavement design is evident.

Specifications.—Engineering specifications more and more recognize the principles that have been discussed in this paper. Specifications are becoming specifications of details. There are concrete, rolled stone, gravel and slag bases bound with screenings and with tar. There are asphalt filler and sand, cement grout or combined tar and asphalt fillers. The sand cushion will be specified to accompany bituminous and sand filler, the cement sand bed or the green concrete base where cement grout filler is used. The specifications will be published in sections. By proper selection a type of brick pavement can be specified that will meet local conditions with economy.

In response to a well defined and growing demand on the part of engineers and the public, for stabilizing the character of its product, the National Paving Brick Manufacturers' Association has adopted the 3 x 4 x 8½-in. square edged brick without lugs as its standard. Already the demand has brought about the exclusive manufacture of this brick by a large portion of the industry and as rapidly as the market for this brick requires it, production will be increased. If it grows at the rate now evident, it will be but a short time before variety in brick types will be a thing of the past. The element of the wearing surface will become stabilized, permitting such variation in bases as is needed the best to meet a given condition.

To sum up the case of brick pavements at the beginning of 1920 based on the indications of 1919, we may state these points as clearly defined:

1. The value of thorough sub-soil drainage is becoming realized, and it is more and more being made an integral part of construction.
2. The use of a variety of kinds of bases to meet different sub-soil, traffic and economic conditions is established firmly.
3. The tendency of design is away from the slab types of brick pavements and toward the types that depend upon the quality of the individual unit as against the monolithic surface.
4. Cement grout filler is being used with more discrimination.
5. The coming year will see the widespread adoption of the standard brick in localities now laying numerous varieties of lug brick.

Cost of Machine Street Sweeping at Boston, Mass.—Machine sweeping of paved streets at Boston, Mass., in 1918 cost 84.3 ct. per 1,000 sq. yd. swept once, according to the annual report of the Department of Public Works for the year mentioned. The total yardage of paved streets swept once was 287,902,945 sq. yd., which is equivalent to 16,358 miles of 30-ft. roadway. In addition 25,154,394 sq. yd. of macadam gutters were swept once, at an average cost of $2.22 per 1,000 sq. yd. A total of 93,134 cu. yd. of dirt, or an average of 0.323 cu. yd. per 1,000 sq. yd. of pavement was removed from the paved streets at an average cost of $2.60 per cubic yard. From the macadam gutters 24,986 cu. yd. of dirt (.993 cu. yd. per 1,000 sq. yd.) were removed at an average cost of $2.234 per cubic yard.

Proper Methods and Bad Practices in Bituminous Concrete Construction

Some interesting points on bituminous concrete pavements were given by Mr. Theodore S. Oxholm, Engineer in Charge of the Bureau of Engineering of the Borough of Richmond, New York City, in a paper presented Feb. 10 at the convention of the American Road Builders' Association. An abstract of the paper follows:

Proper Methods of Construction.—Very often and old macadam road 5 or 6 in. in depth makes a suitable base for a bituminous surface provided drainage conditions are or can be made good. Care must be taken, however, in preparing the old surface to make it as rough as possible so as to prevent creeping of the new surface. The bond of the old pavement must not be broken, for if it is, its value is largely destroyed. Mostly all old macadam roads are now surfaced with road oil, which presents a smooth surface in patches. The best method of removing this oil surface appears to be the old-fashioned one of picking by hand lightly so as not to disturb the bond of the heavier stone. Some roads of this type which have been built by the author are very inexpensive and are giving good service. They are edged with old stone paving blocks set in sand before the bituminous wearing surface is applied.

The subject of drainage is an important one to the road builder. It is generally overdone, resulting in useless cost, or underdone, resulting in great damage to the pavement. It is not difficult for the engineer to tell with approximate accuracy where drainage probably will be necessary and make his preliminary estimates accordingly. Springs and wet places may be noted, and where changes of grades make additional cuts he should be prepared to underdrain when the work is under way and trouble is developed. The old style stone drains, while efficient for a time, usually fill up in a few years and damage is sure to follow. The author uses 6-in. vitrified pipe with open covered joints in all fresh drains, which with suitable outlets will give good service for many years.

One of the most important pieces of road work in the Borough of Richmond which has been completed during the last few years is the paving of the Amboy road, 9 miles in length, through the center of Staten Island and forming part of the main traveled route between New York and Philadelphia, Baltimore and Washington; also New Jersey coast resorts. Three years ago work was commenced on a contract for improving this road with bituminous concrete wearing surface 2 in. thick on a 6-in. concrete base. The pavement was laid 20 ft. wide and concrete edging 6 in. in width was built up monolithic with the base. Four foot earth wings were graded down to a uniform ditch along the sides except where passing through built-up sections where curbs and gutters already existed. The total cost of the work was $330,000, at pre-war prices, and after two years of service the appearance of this pavement is excellent, and practically no repairs have been made. On the first section of about 3 miles it was noticed during the suspension of work for the winter that some transverse cracks had appeared; it was therefore decided to cut ¼ in. joints across the pavement as it was being laid, 300 ft. apart, and fill with asphaltic cement. On the balance of the work this was done and no more cracks have occurred.

As the bituminous material for the wearing surface is brought on to the street it is dumped onto the base and shoveled into place for the rakers. The shovelers tread down the hot mixture so that it becomes compressed before the roller reaches it. This causes an unequal density in the completed work and tends to make the pavement uneven. One method of avoiding this is to have the entire amount of each load of hot mix shoveled and spread in adjoining locations; this causes the breaking up of the portion treaded down and the rakers soon reduce the heavier portions to a uniform surface ready for rolling.

Proper protection to the edges of bituminous pavements should always be provided but often are not. If old paving blocks are not available, either concrete edging or a steel angle iron of proper design and anchored into the concrete base, will protect the pavement from undue wear. The failure to provide this protection soon results in an 18-ft. road becoming reduced to 16 ft. in width, and the narrower it gets the more rapidly the pavement deteriorates.

Bad Practices Which Should Be Eliminated.—The placing of a bituminous concrete wearing surface on top of an old penetration macadam road as a base is sure to result in serious damage to the pavement. Wherever an excess of road asphalt exists in the original pavement it will soften the new wearing surface over it and disintegrate it within a year. While a liberal use of the oil burner in preparing the foundation will improve this condition considerably, yet in the author's opinion this form of old pavement provides a very poor base for a hot mix wearing surface.

Where an old waterbound macadam pavement has been covered with 3 or 4 in. of penetration macadam, and it is desired to place a new wearing surface of bituminous concrete, the author has had good results from removing the penetration pavement entirely, and forming a new crown and repairs to the old macadam with new ¾ in. stone and screenings.

One of the most important defects in bituminous pavements and one which is undoubtedly caused by the great loads being carried by enormous trucks is a pushing forward of the top of the wearing surface, creating waves and ripples that sometimes are so marked that the bituminous material has to be removed and replaced. In the opinion of the author this is caused by requiring a too high penetration test in the asphaltic cement. This has usually been placed at from 50 to 70 in cities near New York, but latterly the Borough of Manhattan has gone to the other extreme and laid pavements at penetration of 30. While the author believes that cracks in bituminous surfaces are preferable to ripples, and can be more economically repaired, yet a medium hardness should be called for. He suggests 45 to 50 and has been laying considerable pavement at 48 during the past summer.

Bituminous pavements adjoining the rails of street car tracks should be protected from disintegration caused by vibration of the rails. In many cities this has been neglected. It is impossible to properly compact the bituminous material under the head and flange of the rails. The vibration during the passage of cars destroys the bond of the bituminous material allowing surface water to enter the space thus formed, resulting in the final disintegration of the pavement. This defect may be obviated by the use of stretcher courses of stone blocks along both sides of the rails. The width of the stretcher area should be sufficient to permit the ordinary rail repairs to be made without cutting into the bituminous pavement.

Another method of construction is to pave up to a steel angle iron laid parallel to and adjoining the rails, the pavement then being practically independent of the railroad tracks.

Iowa's 1920 Primary Road Improvement Program.—The 1920 program of the Iowa Highway Commission for primary road improvement comprises 321 miles of paving, 207 miles of graveling and 1,754 miles of grading. The work involves the following:

Earth excavation	11,463,132 cu. yd.
Rock excavation	71.748 cu. yd.
Gravel surfacing	390,937 cu. yd.
Paving	3.331.545 sq. yd.
Tiling	667,384 lin. ft.
Guard rail	432,347 lin. ft.

The above program does not include paving work contemplated by municipalities, nor the regular county and township bridge and road work. While detailed figures are not available for these items, it appears at this time that there will be at least the usual amount of work done and in the case of municipal work, apparently more than a normal amount of paving work is contemplated.

Road Grader and Truck in Snow Removal.—Heavy road graders hauled by motor trucks have given good service in removing snow from highways of Wayne county, Michigan. For this work the front wheels and tongue of the graders are removed and the frames chained to the truck, making a 6-wheel unit. This equipment does good work in snow up to 14 in. in depth.

Fundamental Considerations for Concrete Pavement Design

By S. T. MORSE,
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The extensive use of concrete for constructing the highways render it highly important that paving engineers thoroughly understand the structural laws and natural conditions affecting the proper design of such roadways. It is to be conceded that the past status of the science has not, as yet, provided generally recognized rules for the guidance of engineers in designing the thickness and form of their pavements. Each engineer, usually, has provided an edge and central thickness based on his particular experience or judgment, and thus the spectacle is presented of some highway departments using an edge thickness of 6 in., others of 7 or 8 in., while some use a central thickness of 7 in. and others up to 10 in.

It, therefore, seems advisable that generally accepted standards be determined and adopted; for, at the present price of 30 ct. per inch of thickness per square yard, the paving engineer, who can without structural failure, by his application of correct methods of design, reduce the specified thickness of a mile of concrete pavement 1 in. has earned his salary for one year. Contrawise, if through a lack of such knowledge, and a desire to construct cheaply, the pavement section is constructed too light, the public has lost much more in maintenance costs and early reconstruction. Therefore with more than $600,000,000 to be expended for road ways in the immediate future, the correct design of concrete pavements has become a question which should at once be placed on a recognized and correct scientific basis.

Considerations Affecting Design of Pavement.—In developing the true method of designing the slab of a concrete pavement, the active external forces must be carefully determined, and the forces of resistance be made equal thereto.

The fundamental considerations which mainly affect the rational determination of the thickness and form of a concrete pavement are as follows:

First—The nature of the foundation, whether it be of muck, clay or sand, whether in a dry, moist, saturated or frozen condition.

Second—The nature, speed and weight of the moving loads which are likely to pass over the pavement, which includes the nature of the tires and springs of the vehicles.

Third—The strength of the concrete to be used, which includes a knowledge of the mixture, the character of aggregate, the amount of water used, time of mixing and the age at time of first major test.

Fourth—The width of the pavement under consideration.

In the light of the present knowledge of the subject, the effect of each of the first three factors may now be determined within rather narrow limits, and the fourth factor is always a known quantity. A brief discussion of the four conditions, and their probable effect on the design, will now be given.

Effect of Subgrade Conditions.—On the nature of the foundation, whether of clay or of sand, whether wet or dry depends the amount of vertical motion transmitted to the edges of the pavement by the freezing of the earth beneath the edges. For more complete details of the action of this factor, see articles by the writer on concrete pavement construction in Engineering and Contracting of July 9, 1913, and Feb. 7, 1917. It has been definitely shown by Mr. J. W. Lowell, see Engineering and Contracting, Nov. 6, 1918, that "the vertical movement or heaving naturally is greatest at the sides where moisture is a maximum and decreases toward the center." It was further shown that the vertical motion of a clay subgrade may equal 7/16 in. and was found to be much less on a sandy subgrade.

Concrete slabs deflect with the movements of the subgrade if their stiffness is not sufficient to carry their weight, and if the deflection becomes great enough, a crack develops along the line of greatest stress, a structural failure is the result.

The writer has observed the upheaval of pavement edges due to frost to be as much as ¾ in. The point or line of application of the summation of these upward or reacting forces becomes the point or line of support for each side of the slab. These lines of support are located at some distance from the edges toward the center of the pavement, and the distance varies with conditions of the weather, and the wetness and character of the subsoil. The distance of the line of support from the center of the slab, being a variable, may be denoted by x, a factor of the span or width of pavement. No definite determination of the extreme location of these lines of support has, as yet, been made, but the maximum stress in a slab is obtained when these lines of reaction approach nearest the edges of the pavement. Through a period of 7 years of close observation of this feature, the writer is convinced that these lines of support at times approach very near to the edge of the pavement where the slab is stiff and strong enough to sustain itself, and in this discussion x will be given a maximum value of 0.95 which is considered safe and representative of the facts.

Stresses in Slab from Moving Loads.—The weight and speed of moving loads which the pavement is expected to support has an effect in stressing the slab second in amount only to that caused by the dead weight of the slab; in fact, it may be shown by the equation hereinafter proposed that a wheel load of 5 tons multiplied by a shock factor of four may cause as much stress in slabs 15 ft. in width as does the dead load under maximum conditions, and that the moving load becomes the major factor in more narrow slabs.

It has been theoretically demonstrated by Mr. J. W. Pearl, see Engineering and Contracting, Feb. 11, 1914, that a concentrated load on a concrete slab is distributed over a circular area which has for its diameter, approximately, the width of the slab, within certain limits, and that the bending moment $M = Pr/4$; equating to the resisting moment,

$$\frac{Pr}{4} = \frac{2\pi rft^2}{6};$$

from which Equation 1 is $t^2 = P/4f$, where t is the thickness of the slab, P the load, and f the unit stress.

For further discussion of the effect of static loads on slabs, see article by Mr. E. B. McCormick before the 11th annual convention of the American Concrete Institute, Feb. 9, 1915, and Bulletin No. 28 of the Ohio State Highway Department.

In Equation 1, there is no provision made for including the effect of shock which arises from moving loads. The amount of shock depends on the weight, the speed, roughness of the road surface, kind of tires, and the springs, and in all previous efforts to evolve a correct equation expressing thickness the writer, and no doubt others, have been hindered by this unknown shock quantity which may be represented by the symbol y, and Equation 1 becomes $t^2 = yP/4f$............(2)

The U. S. Bureau of Public Roads has recently been making these much needed impact experiments, and while a full report has not yet been issued, the important results have been reported by Mr. A. T. Goldbeck, its testing engineer, in a paper abstracted in Engineering and Contracting, Dec. 3, 1919. Quoting from this paper, "The indications are that when a wheel load of 8,500 lb. is at rest on an 8-in. concrete slab laid on a rather wet subgrade the fibre stress in tension is only about 34 lb. per square inch directly under the load." Substituting the above known quantities in Equation 1 and solving for the real value of the factor of f in the equation, we find that $8^2 = 8{,}500/z34$, or $z = 3.9$ which is a very practical verification of the theoretical value 4 in Equation 1. With this verified value of the factor of f, further investigation may proceed with confidence.

In his paper Mr. Goldbeck stated that "The highest pressure thus far measured being in the neighborhood of 42,000 lb. when the weight on the rear wheel causing this pressure was only 7,750 lb. The unsprung weight on one rear wheel of this truck was 1837 lb." This pressure was very exceptional, and the experiments show, in general, that the maximum pressure caused by impact was about four times the static weight of the wheel load, from which a fair value of the factor y may be placed at 4. Using the highest pressure found, viz. 42,000 lb., under the conditions named the unit stress developed could not exceed about 165 lb. per square inch according to Equation 1, from which it must be conceded that the moving load is but one of the rather minor factors affecting the design of concrete pavements.

Resisting Moment of Concrete Slab.—The third fundamental affecting road design has to do with the resisting moment of the slab itself. The resisting strength of a concrete slab is controlled, mainly, by the relative amount of cement used, the grading and quality of the aggregate, the amount of water, the time of mixing, and the age of the slab at the time of stressing. A short consideration in detail of these factors will be given, following the discussion of the form design.

Quoting again from Mr. Goldbeck's recent paper, "The modulus of rupture of the ordinary concrete road mixture is well over 400 lb. per square inch, and possibly as much as 600 lb. per square inch." These values of f are substantiated by tests of Prof. A. N. Talbot, and by tables of Taylor and Thompson; so that with a concrete mixture of 1:1½:3, a conservative value for f may be assigned at 400 lb. Also, with a mixture of 1:1:2, according to all available tests, it is quite as conservative to assign a value of 500 lb. to f, the modulus of rupture, which leads at once to the very interesting conclusion that a concrete pavement of equal strength may be designed as cheaply with a mixture of 1:1:2 as one of 1:1½:3, and, according to the recent tests, of Prof. D. A. Abrams, the abrasive resistance increases as the strength of concrete increases which indicates that at least 30 per cent more wear may be expected from the richer mix at the same cost. This idea is injected for future consideration, and it is hoped, will not cloud the issue directly in hand.

Effect of Roadway Width on Thickness of Pavement.—The width of the pavement has a most important bearing on the road design in that it is properly the span of the beam considered; and by the laws of flexure it enters the problem as its square; the equation for the moment of a simple beam being

$$M = \frac{w(x\ 12\ L)^2}{8},$$

in which w equals the weight per square unit $= t/12$, and L equals the width of the pavement in feet.

Equating to the resisting moment,

$$\frac{12t(xL)^2}{8} = \frac{fbt^2}{6}, \text{ from which}$$

$$t^2 = \frac{9t(xL)^2}{f} \quad \dots\dots\dots\dots\dots\dots\dots\dots\dots (3)$$

Equation 3 indicates that the thickness of concrete pavements must be increased as the square of the width increases, nearly. Since the present tendency is to increase the width of roadways to a minimum of at least 20 ft. for all double traffic roads it is very evident that accurate knowledge of the design necessary to fulfill the structural requirements should be at once at hand to the end that the $600,000,000 available for immediate construction may be expended without undue structural failure, and with the full assurance that there is not material waste by uneconomical design of form and thickness. Quoting Mr. Goldbeck, "In the face of such an enormous program it behooves us to build wisely lest we be extravagant either by too much or too little initial expenditure for our various road systems." We must not be satisfied with a constant cross-section irrespective of the fundamentals affecting road design.

Formula for Design of Concrete Slabs.—Having considered in the above discussion the fundamental conditions which affect the design of concrete road slabs, a fundamental formula for the rational design of concrete slabs placed on shallow, unstable foundations may be derived.

Since the bending moments are proportional to the square of the thickness of the slabs Equations 2 and 3 may be combined and

$$t^2 = \frac{9t(xL)^2}{f} + \frac{yP}{4f} \quad \dots\dots\dots\dots\dots\dots\dots (4)$$

from which the general formula is obained,

$$t = \frac{4.5(xL)^2}{f} + \sqrt{\frac{yP}{4f} + \frac{20(xL)^4}{f^2}} \quad \dots\dots\dots\dots (5)$$

Giving x the value 0.95. and y the value 4 as determined in the above discussion,

$$t = \frac{4L^2}{f} + \sqrt{\frac{P}{f} + \frac{16L^4}{f^2}} \quad \dots\dots\dots\dots\dots\dots (6)$$

which, using $f = 400$ with a concrete mixture of 1:1½:3, becomes

$$t = \frac{L^2}{100} + \sqrt{\frac{P}{400} + \frac{L^4}{10,000}} \quad \dots\dots\dots\dots\dots\dots (7)$$

and using $f = 500$ with a concrete mixture of 1:1:2 Equation 5 becomes

$$t = \frac{4L^2}{500} + \sqrt{\frac{P}{500} + \frac{16L^4}{250,000}} \quad \dots\dots\dots\dots\dots\dots (8)$$

The writer presents general Equation 5 to the paving world for guidance in the rational design of the central thickness of concrete pavement slabs with entire confidence that it will be found correct in form, convenient to use, and that it will provide safe weights within the assumed conditions of service. The thicknesses given will prove to be slightly excessive for pavements built on sandy foundations which will give opportunity for the exercise of good judgment. guided by the formula.

As an illustration of the value and applicability of a rational. recognized method of designing slabs, consider the concrete road being built from Mt. Clemens to Detroit which is reported to be 8 miles in length, 24 ft. in width and 10 in. in thickness. Applying Equation 4, it is found that, with a clay subgrade, the unit stress as planned may run as high as 560 lb. per square inch which is too high for most concretes, and unless all of the foundation is quite sandy, a number of structural longitudinal failures are likely to occur which will require considerable maintenance expense. Either the central thickness should be increased to 12 in.; or better, two parallel, adjoining slabs 12 ft. in width may be constructed with a uniform thickness of 7 in., which on this road, estimating the cost at 30 ct. per inch of thickness per square yard, will save in first cost $12,000 per mile, or a total of $96,000 on the job. If 10 per cent of the amount saved be placed at 5 per cent interest it will return $60 per year per mile as a maintenance fund which is much more than well built concrete roads have been costing to maintain. There are many extravagant examples of this character. It seems important that a recognized system of design should be generally adopted. The writer has eliminated the longitudinal crack from pavements of his construction.

Design of Mixtures.—The quality of materials, their proportions, the grading of the aggregate, the amount of water, the time of mixing determine to a large extent the strength and abrasive resistance of the road.

Cement.—Considerable difference still is found in the fineness, strength and soundness of the various brands of cement. The quality should meet the requirements of the A. S. T. M. standards. The writer requires a tensile strength of 700 lb. per square inch 28 days after mixing. The care and expense incurred in procuring the best of other materials and proper workmanship must not be discounted by the use of poor cement.

According to all available tests, there is a very marked increase in the strength and durability of a concrete having a mixture of 1:1:2, over one having a mixture of 1:1½:3, amounting to approximately 40 per cent additional strength with about 37 per cent more cement. The modulus of rupture and the abrasive resistance appear to be likewise increased. With an increased knowledge of the design of pavements, the writer has the temerity to suggest that within the near future, the first-class roads will be constructed with a mix of 1:1:2, and at no greater cost per square yard.

TABLE I.—REQUIRED THICKNESS AND RELATIVE COST PER SQUARE YARD OF WIDE AND NARROW PAVEMENTS.

P = 10,000 lbs.

Concrete mixture.			Estimated cost per inch per sq. yd.	—Road width, 10'.—		—Road width, 12'.—		—Road width, 16'.—		—Road width, 20'.—	
Cement.	Sand.	Stone		Thickness required. t.	Cost per sq. yd.	Thickness required. t.	Cost per sq. yd.	Thickness required. t.	Cost per sq. yd.	Thickness required. t.	Cost per sq. yd.
1	1½	3	30 ct.	6.1"	$1.83	6.64"	$1.99	8.17"	$2.45	10.4"	$3.12
1	1	2	35 ct.	5.34"	1.86	5.78"	2.02	7.05"	2.47	8.22"	2.88

Aggregate.—The grading of the aggregate should be made the subject of much consideration. The fund of information concerning correct grading has recently been much increased by the many tests made by Prof. D. A. Abrams of the Lewis Institute, Chicago, who has clearly defined and uses what he terms the "Fineness Modulus" as the standard guide for determining the correct grading of the aggregate. The writer finds this method easily workable, and definite in its results. In preparing specifications, it seems advisable to provide a definite proportion, such as 1:2:3 with the added clause, "Except that when the 'Fineness Modulus' as defined by Prof. D. A. Abrams in Bulletin No. 1 of the Structural Materials Research Laboratory, Lewis Institute, shall be less than 5.5 then the above specified 2 parts of sand shall be reduced in quantity, and when the said 'Fineness Modulus' shall exceed 6.0, then the amount of sand used shall be increased in excess of the specified 2 parts." Such a specification provides a definite basis for making estimates of cost and quantities, and a definite system for properly grading the aggregate; it requires that the engineer in charge shall have, and use frequently, a set of standard sieves, which each paving engineer should possess.

Water.—By his many tests, Prof. Abrams has also proved the first importance of holding the amount of water used, relatively to the amount of cement used, at the lowest possible point which will provide a workable mixture. He has shown that by decreasing the water used in mixing from an amount of 100 per cent to an amount of 85 per cent of the quantity of cement used, the strength of the resulting concrete is increased as much as 25 per cent. Hence, if the modulus of rupture "of the ordinary concrete road mixture," as stated by Mr. Goldbeck is as much as 400 lb., then the modulus of rupture of a concrete mixed with the correct amount of water would be at least 25 per cent more or 500 lb., and applying Equation 6 for required thickness for a road 16 ft. in width, we find, using the dryer mixture, that the required thickness is 7.05 in. as against 8.17 in. for the ordinary wet mix, or a real saving of 1.12 in. in thickness of concrete, which at 30 ct. per inch per square yard will save $3150 per mile of road 16 ft. wide. It is to be conceded that the dry mixture requires more labor and time in construction, but the above amount of saving will pay the contractor for considerable time and trouble, and also provide for considerable added inspection, moreover ways and methods will speedily be found to reduce the added cost of the dry mix to a negligible quantity. The above determination is but another illustration of the advantage of having for use, a formula and recognized system of design for concrete roads.

Such tests as those made at the Lewis Institute are welcomed by all engineers, and certainly great credit is due Prof. Abrams.

The above stated methods of design will provide a concrete pavement with sufficient central thickness and strength to prevent the central longitudinal cracking, so frequently observed, and will also assist designers in avoiding extravagant and excessive central thickness toward which the tendency now is.

There yet remain for discussion and solution, the questions of edge thickness, and the elimination of transverse cracks. It may ultimately be determined that the forces which produce the majority of transverse cracks are also the forces which will govern the required thickness of the slab at its edges. The writer is investigating this phase of the subject in particular, and has made at least one unexpected and interesting discovery. Experiments, looking toward the entire elimination of transverse cracks, also, are in progress, but results will not be available for another season.

305,000 Motor Trucks Made in 1919.—A total of 305,000 motor trucks were made last year, according to the Commercial Vehicle, which also predicts a production of 370,000 trucks in 1920. The production by years since 1909 has been as follows:

1910	9,500	1915	74,000
1911	18,000	1916	98,000
1912	25,000	1917	190,000
1913	28,000	1918	250,000
1914	35,000	1919	305,000

Rhode Island Practice in Bituminous Macadam Construction

Excellent examples of bituminous macadam are to be found in Massachusetts, Connecticut and other eastern states. Interesting information on the practice in some of these states was given by Mr. J. E. Pennybacker, Secretary of the Asphalt Association, in a paper presented Feb. 10 at the convention of the American Road Builders' Association.

Rhode Island has on its main trunk line highways bituminous macadam constructed in 1913, at an average cost of $1.09 per square yard and maintained at an average cost estimated by the chief engineer at less than $50 per mile per year. He states that in no case has maintenance cost over $100 per mile per year, while on one of the sections there has been absolutely no maintenance of the metal surface to date.

Mr. Patterson, the chief engineer, points to no fundamental changes in the type of construction as originally designed, but emphasizes certain faults which he found it necessary to avoid and certain qualities which he sought to attain. Thus he points out as the fault most commonly noticeable in the bituminous macadam the waviness or corrugation of the wearing surface, and he ascribes five causes to which this is due, namely, (1) the use of asphalt of too high penetration; (2) excessive amounts of binder; (3) crushed stone of too small sizes in the wearing course; (4) soft stone in the wearing course and (5) inferior construction methods. That his conclusions were sound, the results he obtained have demonstrated.

Experience in New York State with the bituminous penetration type has covered a period of about 10 years, during which about 3,000 miles have been constructed. Of this entire mileage only about 100 miles, or about 3⅓ per cent, have been resurfaced or reconstructed. Of about 730 miles built in 1911 and 1912, 6½ per cent has been resurfaced or reconstructed. This shows that with an average age of 7 years, only a little over 7 per cent has been resurfaced or reconstructed. The maintenance costs during 1915, 1916 and 1917 averaged $464 per mile per year, including shoulder work.

Many of these roads were laid upon subgrades which were not adequately drained, and most of them were built to sustain a traffic far lighter in weight and smaller in volume than they have actually been called upon to sustain.

In the Rhode Island practice an asphalt having a penetration of from 90 to 100 is used in place of the softer asphalt. The binding application is made at the rate of 1¾ gal. per square yard of surface and the seal coat at the rate of between ¾ gal. and 1 gal. per square yard of surface, the quantities thus corresponding to the general practice of this type of surface.

Both Rhode Island and New York practice involves the use of crushed stone, in both the base course and the wearing course, of uniform sizes, passing a 2½-in. screen and retained upon a 1½ screen. The depth of the wearing surface is made 2½ in. thick after compression.

An interesting comment by Chief Engineer Patterson of Rhode Island on the foundation problem is, that while the bituminous surface ultimately is very nearly waterproof and has a tendency to keep the sub-soil dry, the capillarity of certain sub-soils is so marked as to make the waterproofing of the surface sometimes of little avail. In studying this characteristic of sub-soils, the engineers make very careful examination of conditions during a winter thaw, followed by an examination in the early spring, when the sub-soil is well saturated and when the frost is completely out of the ground. The Rhode Island practice is to employ a stone fill, avoiding telford as well as crushed stone, for the foundation proper. The stone foundations are constructed ordinarily of field, wall or ledge stone of sizes varying from 3 in. to 15 in., and the foundations vary in thickness from 6 in. to 18 in.

Utah Road Engineers Ask Increase in Pay.—Employes of the Utah State Highway Department have petitioned the State Highway Commission for increases in salaries as follows: Instrument men, from $135 to $150 to $200 a month; inspectors, from $150 to $200 a month; resident engineers, from $175 to $225 a month; district engineers, from $200 to $250 to $300 a month; draftsmen, from $150 to $160 to $215 a month; chief draftsman, from $200 to $225 e month; bridge engineer, from $225 to $330 a month.

Surface Treatments on Macadam Roads *

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Much of the dissatisfaction with surface treatments on macadam roads has arisen not through any fault of the system but on account of the attempt to salvage pavements that have gone so far that they could not be retrieved by so simple a method, or where they were subjected to traffic that called for a heavier duty type of pavement. It was the engineer's judgment that was at fault, not the method.

The choice of the bitumen too has often been at fault. Dust laying oils and raw tars have been confused with the more permanent refined tars and asphalts which alone will be considered here. Dust layers simply weight the dust particles and prevent their blowing about. The heavier bitumens prevent dust by binding and protecting the road surface, either by penetration into the road crust or by forming protective mats of bitumen and stone upon the surface.

Many of the old macadam pavements have worn thin or have ground up internally under traffic weights that they were not designed to carry. Obviously in theory but seldom in practice, these old road crusts should be strengthened and drainage errors corrected before successful surface treatments can be expected. With soft rocks it may even be necessary to strengthen the crust by employing some of the modified penetration methods, using the thinner tar or cut-back asphalts applied cold as practiced in Maryland and Wisconsin.

Surface Treatments for New Macadam.—Where new macadam is built, it should be so constructed that surface treatments can be successfully applied soon after or even before the road is opened to traffic. The old tenets of good macadam construction are too well understood to dwell upon here. Suffice it to say that drainage and foundations should be good, that the design should be equal to the loads that are to be imposed, that the road should be built of good materials, properly rolled and properly filled and bonded.

The surface must be given particular study. It must be remembered that the final surface produced is a bituminous surface. The contour should be therefore not that of a macadam road but that of a bituminous road. A camber of ¼ to ¾-in. is plenty. A greater crown than this makes a slippery road.

The material for the surface course should be carefully chosen. The stone should be as large as can be made to bond in place. For a soft stone sizes grading from 3 in. down to 1¼ in. are not too large. With trap rocks and hard stone, ¾-in. to 2-in. may not be too small, if the pieces of different sizes are well graded.

The kind and amount of bonding material are of great importance. Usually stone chips and stone dust of the same material as the stone used give the best results, but with soft limestones a graded clean gravel from ¾ in. down to ⅛ in. often gives superior results if intelligently used. The aim should be to thoroughly fill the voids in the stone by flushing in the filler with alternate watering and rolling until the surface is solid.

Extreme care should be observed to leave no layer or cake of screenings on top of the stone composing the surface. If any such layer remains it is often impossible to surface treat the road successfully.

Clay and materials that produce slime should be religiously avoided in the top course as they form emulsions with bitumens and the coating sloughs off.

The aging of the macadam before it received the bituminous treatment has of late years been the subject of much study. With the heavy mat coats, it is important that the macadam be thoroughly set up by aging before the application is made. The cementing value of the soils used, the traffic and moisture conditions, are factors in the setting up process. Usually, six weeks to two months in the spring and summer are sufficient. Pavements finished in the fall may be carried through the winter by using calcium chloride, and then the bituminous treatment given as early as practicable in the spring.

If cut-back bitumens, applied cold, are used, it has been found possible to greatly shorten the aging before the application, and even if care is used, to apply the bitumens on completion of the road. With soft rocks and rocks of low cementing value, new possibilities are indicated by these methods of early protection against automobile traffic.

The refined tars applied cold have given particularly satisfactory results in this field and even where subsequent treatments have been made with asphalts, the first use of tar applied cold has been found advantageous.

Whether a macadam road is old or new it must be very thoroughly cleaned before surface treatments are applied. Brooming with steel wire rotary brooms followed by local hand work is good practice and care must be taken to clean the pavement down to clean stone. Caked material or dust on the surface prevents the bitumen from penetrating and from bonding onto the stone. Hot blanket coats require particularly thorough cleaning of the road. Sometimes a priming coat of cut back bitumen applied cold helps in forming a bond.

The choice of one bituminous material that can be used to solve all the surface treatment problems that arise is a manifest impossibility. The kind and grade of bitumen must be varied to suit the kind and the size of stone used in the road crust, the expected volume and character of traffic, and its distribution through the seasons and the climatic conditions, and in the face of all these variants, a choice of material and method is more often controlled by the funds available.

It pays to make a close study of local conditions and to get the benefit of the combined experience in any locality.

Amount and Kind of Cover for the Bitumen. This subject offers just as interesting a field for study as the bituminous materials themselves. The choice is often limited to what is available locally, but given a variety to choose from, little chance of mistake is made in choosing the hardest material possible and in using the largest sized particles that will be held on the road by the bitumen. The amount used should be the least possible to protect the surface from picking up under traffic. It is better to add more subsequently than to use too much at first. A big excess wastes bitumen and may even destroy the coating by furnishing mineral aggregate in excess of the binding power of the bitumen.

Treatments of hot bitumens to be successful require good hard cover of the correct size. Unless this is used rolling and rutting are almost sure to occur. Stone as large as ¾ in. to 1¼ in. may sometimes be used to advantage.

As the cover and its application form a considerable part of the expense of surface treatment the economic cost factors should be thoroughly studied. Some bitumens require much more cover than others and some require more expensive cover. As this extra cost may be in part offset by greater durability, the problem should be viewed from every angle.

Re-treatments.—Re-treatments call for special study as the conditions are essentially different from the first treatment. Usually little sweeping is required and the patching is a much easier matter or may even be deferred until after the treatment is applied. As a rule the quantity of bitumen required for re-treatment is much less than for the original treatment. The road is already saturated with bitumen and a renewal and enlivening of the surface is generally all that is required. A macadam which absorbed ½ gal. originally can usually be re-treated with ¼ gal. In subsequent treatments the amount may be still further reduced to advantage. Thickening of the mat is in most cases to be avoided, as it leads to rolling and rutting of the surface. Sometimes the same end can be gained by using a thinner bituminous material applied very sparingly.

The care and maintenance of surface coatings requires careful thought to make it economical and effective. No surface treatment should ever be applied unless provision is made for taking care of the surface. The introduction of cold patching materials has made the care of surface treatments much easier. Much is gained by patching breaks and abrasions as soon as apparent. For this reason patrol maintenance is particularly effective in taking care of surface treatments. Equally good results may however be obtained by gang maintenance with automobile equipment provided recurrent trips are frequent.

Surface Treatment of Gravel Roads.—Surface treatment of gravel roads with anything more than dust layers may be said to be more or less in the experimental state. The distinct successes measured in permanence to date have been on gravel roads that to all intents and purposes were macadam roads. In discussing the question, the term gravel must be distinctly defined. The term is applied to a great variety of materials of differing sizes and mineral content.

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*From a paper presented Feb. 10 at the convention of the American Road Builders' Association.

In addition to variations in the material, gravel roads are built under widely varying specifications. No lasting surface treatments on a gravel road are possible unless the road as constructed is capable of sustaining the traffic that goes upon it. A surface treatment cannot supply drainage, a foundation, a base, or a thick bituminous wearing course. All that can be expected of it is to supply a protective coating that will conserve the surface from the abrasion of automobile traffic. Whether this coating is lasting or not depends wholely on the sustaining power of the structure.

Even if they are not lasting these treatments may be economically justified. Gravel roads in the northern states when well built and properly maintained are never out of condition more than one month of the year, and that is in the spring when heavy hauling of any kind is usually out of the question in these districts. The lumber hauling is done on the snow and the crops are moved in the fall when the gravel road is at its best. The better road is hardly justified economically in many situations and yet something must be done to hold these roads against automobile traffic.

The untreated gravel roads of the glaciated states are of great economic importance since they may be built at a comparatively low cost and will sustain light traffic successfully. Traffic censuses on roads of this class show that they will take care of about 200 automobiles per day with the ordinary gravel maintenance methods of dragging and patrol. Beyond this traffic the surface becomes loose and the disintegration of the surface becomes serious. Dust laying oils alleviate the dust nuisance, but the oil destroys the natural bond of the gravel and causes much potholing.

In Main and New Hampshire a system has been worked out using cold refined tars that enable these roads to carry 2,000 to 3,000 automobiles per day through the summer season. For the winter and spring the road crusts may break up, but as the traffic on these roads at that time is extremely light, and not of a heavy loaded type, it militates little against the success of this type of road and the surface treatment.

For the first treatment the road is dragged into good condition in the spring, with addition of new gravel if necessary. Application of sufficient gravel to amount to more than 2 in. should be made in the fall. After the road has dried out and hardened under traffic, it is swept with horse brooms and the first application of cold refined tar applied. This is allowed to soak in without cover. A second treatment is then given. This is left without cover for 4 to 6 hours of sunshine and then if any liquid remains on top, enough cover is used to blot up the excess.

Patrol maintenance is given these roads and is necessary to economically maintain them. All bank gravels run uneven, so that dust pockets exist in these roads which sooner or later break out. The breaks are easily repaired with tar and gravel, if attended to immediately, but if neglected spread and threaten the whole road.

The roads may or may not break up in the spring, depending on the road and the weather. After hard winters such as 1917-18 they do not break. After open winters like 1918-19 the road usually breaks when the frost is coming out of the ground. In case the road does not break, it is repaired and re-treated like a macadam road. In case the road breaks, it is shaped up and dragged back into condition like an ordinary gravel road. In either case, a single re-treatment of ¼ gal. per square yard is usually sufficient to put the road in good shape for the season's traffic.

If the road goes through several seasons without breaking up, it is usually necessary to break it artificially as the road through frost action and heavy traffic gradually loses its shape. A road roller with spikes in the wheels, a steam scarifier and a harrow are effective tools on this work. After the road is re-shaped it is re-treated and maintained as before. However, as the gravel is stuck together in lumps, the road acts more like a macadam and will go a much longer period before it requires breaking a second time.

Cost Plus Bid for Highway Construction

The Highway Commission of Maricopa county, Arizona, received bids Jan. 12 for constructing highways under a bond issue of $4,000,000. Proposals were asked on the entire program of 278 miles. But one proposal was submitted, and this was rejected. The one bid was on a cost plus basis, with 6 per cent and rentals for equipment for a profit fee. The bid was submitted by the Shattuck-Edinger Co., Los Angeles, Calif., and was as follows:

Pursuant to your notice to contractors, copy of which is hereby attached, we herewith submit to you our proposal for the construction of 278 miles of highway, the authorized road program of Maricopa County, Arizona. We herewith accompany this proposal by a certified check in the amount of two hundred thousand ($200,000) dollars. Said check is drawn upon the Valley Bank of Phoenix, Ariz., a solvent bank located in Phoenix, Ariz., and is payable on sight to the Maricopa County Highway Commission.

We hereby propose to furnish all labor and materials, equipment, work, stock, plant, tools, appliances and machinery for the construction and completion of the two hundred and seventy-eight (278) miles of highways provided for in your specifications and plans therefor; said work to be constructed and completed in accordance with said plans and specifications.

We will furnish all labor and materials, equipment, work stock, plant, tools, appliances and machinery, necessary for the construction and completion of said work, and will pay all costs of the work and shall receive from the commission all costs of work, rentals hereinafter set forth or provided for, together with six per cent (6%) of all said costs of work and rentals for our profit fee; provided, however, that in no event shall the amount of such profit fee exceed the sum of four hundred thousand ($400,000) dollars.

Costs of work shall include all costs of labor and materials for operation of the work, whether such materials are furnished by the Maricopa County Highway Commission or the contractor, compensation insurance premiums for labor, fire insurance, costs of obtaining and transporting labor; accounting, timekeeping and superintendence; all costs of supplies and labor for operation of boarding houses; all costs of repairs, upkeep and maintenance of stock and equipment employed upon the work; all cement, lumber, hardware, powder and other construction materials required for the work; all equipment, plant and stock rentals hereinafter set forth; hay and grain, feeding, shoeing, boarding houses and sleeping quarters, tents and equipment therefor; premiums on bonds, if bonds are required; all expenses including freight, of moving complete outfit from initial points of shipment to sites of work, and all necessary expenses for the completion of the highways.

All work to be done under the direction and to the approval of the commission or its engineer.

The commission, through and by its engineer, shall have the right of approval or disapproval of all purchases of materials and prices paid labor hereunder.

Rentals shall be as follows, to-wit:

RENTALS OF EQUIPMENT.

Crusher Plant—1 No. 8 gyratory crusher, 1 No. 6 gyratory crusher, 1 No. 3 gyratory crusher, 1 sand roll, 1 150 h.p. motor, 1 75 h.p. motor, 1 30 h.p. motor, 1 15 h.p. rock screen, No. 8; 2 15 h.p. rock screens, all counter shafting and belting, conveyors, elevators, 1 air compressor, 1 50 h.p. motor, 1 mile of steel rails (track mile); 1 5x6 Triplex pump, 1 4x6 Triplex pump, 5 cylindrical tanks, 1,500 gallons each; 4,000 feet 2-inch pipe, 1 blacksmith shop equipment, 2 screens for No. 8; total flat rental, $30,000.

PAVING EQUIPMENT.	Per month.
Paving mixers, 1 cu. yd. capacity	$ 610.00
Mechanical tampers	150.00
Triplex pump, 4x6	37.50
Gas engines, 10 h.p.	37.50
8 miles 2-in. pipe at 50 ct	1,760.00
150 wheelbarrows at $14	175.00
4 miles single line steel forms and pins	1,170.00
8 shapers	350.00
5-ton trucks, power dumps	600.00
3 5-ton trucks	450.00
Ford autos	60.00
Buick autos	150.00
Ford trucks	100.00
Derricks with clamshell buckets	500.00
Roller, 12-ton	1,500.00

GRADING EQUIPMENT.

Stock and harness, Fresno equipment with necessary camp wagons, boarding house equipment, all necessary camp equipment, except lumber, $15 per head per month.

Blade graders, $70 per month; dump wagons, $20 per month.

Sand Plant at River—1 No. 4 gyratory crusher, 1 screen, 1 50 h.p. motor, 1 elevator, 1 belting countershaft, 2 Lidgerwood drag lines complete with hoist, buckets and attachments; rental rate, $2,000 per month.

All miscellaneous small tools and fitting to be part of cost of work and remain property of the commission. Any additional equipment found necessary to be furnished at going rental prices and terms to he agreed upon between contractor and commission.

Payment of rental for such machinery in main crusher plant as listed above to be furnished hy contractor for use in the crusher plant under flat rental. shall be made monthly in proportion to the percentage of completion of work or total construction expenditures as the contractor may elect.

All necessary buildings shall be erected at quarry sites and freight points out of timber and shall be at the cost of the commission and remain their property and all such labor and material shall be part of cost of work. The contractor to receive no further rental on equipment under terms of this contract when the rental amounts to the entire cost of equipment to the contractor; and thereafter it is agreed that no further rental shall be charged, and same shall become property of the county. This does not include any machinery at main crusher plant for which we are making flat rental charge of thirty thousand ($30,000) dollars; nor does it include any teams and team outfits.

Any equipment, plant, tools, appliances and machinery, the purchase of which shall have been charged to the commission as a part of the cost of work, and for which no rental charge has been made, shall remain in our possession and exclusive control untit the completion of the work and thereupon shall become the property of the commission.

We will give security for the faithful performance of our contract with sureties to be approved by the commission, in such amount as the commission shall determine.

All stock, outfit, plant and equipment furnished by us shall go upon the work in first-class working condition.

Any of our employes not satisfactory to you to be replaced by us.

All bills due us from you hereunder in any month to be paid to us hy you within ten (10) days after presentation.

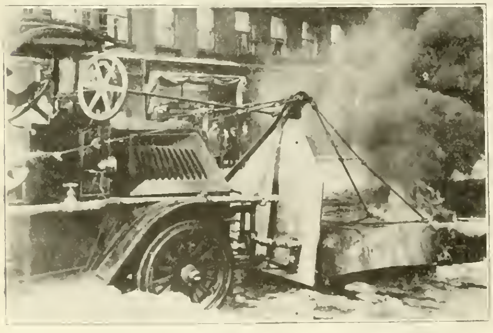
We will present to your representative upon the work daily field reports showing labor employed, materials purchased and stock and equipment used.

All rentals on outfit, stock, equipment, plant and items for which rentals are charged herein shall commence when same are loaded on cars for shipment at initial points of shipment.

in accordance with this proposal and your plans and specifications conditions as shall be agreed upon between us.

Oil Burning Snow Melter

The recent heavy snow-fall in eastern cities resulted in the trying out of several new types of snow removal apparatus. One of these consisted of an oil burning flame projector. This device was invented by L. V. Stevens, a Canadian engineer, and has been used on the Canadian Pacific R. R. It is shown in the illustration mounted on a 7½-ton Mack truck. The truck carries an 1,800 gal. tank of crude oil and travels at the rate of 5 miles per hour. The device throws an incandescent flame some 10 ft. ahead. The oil and air are both forced ahead under compression through a mixer or carbureter, in a manner similar to the practices established in the case of blast furnaces and oil burning locomotives.



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Snow Melter in Operation in Brooklyn.

Illinois County as Unit for Road Work.—Highway superintendents of Illinois Counties adopted a resolution at their annual meeting last month in favor of county units for road work rather than township units, because of the large taxing power. The plan may come up for consideration at the present session of the constitutional convention.

Motor Fees As a Basis for Bond Issues for Road Improvement

By S. E. BRADT,

State Superintendent of Highways of Illinois.

The clippings that come to my desk indicate that some people far away from Illinois and unfamiliar with Illinois conditions are taking occasion to criticise our plan of promoting highway construction. These same people claim to speak for the motorists of the country, saying that the motor fees should be set aside for maintenance purposes, rather than for construction or a basis for bond issues. They claim that the use of motor fees for construction purposes is inequitable because all people receive a benefit from road improvement and that the direct benefits to the motorist are incidental and secondary.

Who are these motorists whom they claim to represent? Are they a separate and distinct class of our people separated by a peculiar profession or occupation? The fact is that these motorists are the farmer, the miner, the merchant, the mechanic, the banker, the shopman, the lawyer, the doctor, the preacher and finally the legislator, who makes our laws. They are the men who approve or disapprove through their ballots all unusual matters of taxation which include bonds and special levies for road improvement. They pay 100 per cent of the motor fees; and probably over 90 per cent of the general taxes. There are at the present time approximately 7,500,000 cars registered in the United States. Later estimates claim the number registered will be 10,000,000 by the end of 1920. Counting a car to a family of six persons you will find that 45,000,000 of the 110,000,000 of the people are motorists in the proper sense of the word. In the state of Illinois these motorists constitute approximately 50 per cent of the population and hence 50 per cent of the voters and if they are 50 per cent today they will soon be 60 to 75 per cent. It is from this 50 per cent of our people that 90 per cent of the legislators are drawn. This proportion is not the same in all states. In some of the states the motorists are more than 50 per cent of voters; in other states less; but they constitute the active, influential force in every community and every state.

This motorist is a man who thinks for himself. He knows conditions in his own state and he knows public sentiment. He has assigned to no individual or organization the right to speak for him; he has no advocate or special pleader; no one holds a brief for him. He will brook no interference from special interests either outside or inside of his state. He is his own boss; and if he prefers to take the money for highway improvement out of his right hand pocket or his left hand pocket, it is his money and his own affair; and you can depend upon it that he will settle that question without interference or assistance.

These clippings indicate that the writers are not familiar with the Illinois plan. They give the impression that the entire road improvement in Illinois is paid from motor fees. The fact is that the people of Illinois have said that the state-wide system of 4,800 miles shall be improved from the proceeds of bonds, which are to be liquidated from motor license fees. This 4,800 miles constitutes, however, only 5 per cent of our 96,000 miles; thus there remains 91,200 miles to be improved by general taxation and the motorist, instead of being called upon to pay the entire cost of highway maintenance and improvement in the state of Illinois, is only paying for the improvement and maintenance of 5 per cent of the Illinois roads. To show what is being done by general taxation let me say that the counties of Illinois have already voted approximately $15,000,000 in bonds for road improvement; and if satisfactory conditions for construction, as to car service, supplies of material, labor and contractors, could be relied upon so as not to interfere with the state program, not less than $75,000,000 additional would be submitted to the voters in about 40 counties of Illinois during 1920.

All county bond issues must be paid by general taxation. It is not necessary to state that during the life of the bonds which are to be issued by the state and paid by motor fees a sum several times as large will be voted by the counties and townships to be paid by general taxation.

Illinois has at the present time approximately 600 miles of hard surfaced, state constructed roads which it is obliged to maintain and which it is maintaining from motor license fees with about $100,000 per year. The remaining roads of the state are maintained by the local authorities which heretofore have been raising about $8,000,000, but which hereafter are entitled to raise in excess of $12,000,000 per year for that purpose. The revenue from motor fees is in excess of $5,500,000, with only $100,000 reserved for maintenance. What would our friends suggest that we do with the $5,400,0000?

With the maintenance of our roads taken care of and only a very small part of the roads properly improved, the voters of the state decided by a vote of 660,000 to 154,000 that this money should be made a basis for bonds and the proceeds of the bonds used to construct a system of main traveled thoroughfares, the construction to be of such type as would give a maximum amount of service at a minimum maintenance cost. A more equitable and sensible solution of the problem could not well be devised.

As I have indicated, Illinois is at present maintaining and proposes in the future to maintain its state roads from motor license fees and it is apparent that these fees will not only maintain these roads but will furnish sufficient funds to retire the bonds which we propose to issue for construction.

Some critics contend that the motor tax is inequitable and uneconomic when used for construction purposes, because, as they claim, it fails to recognize the fundamental basis of taxation, namely, that the taxes should be levied in proportion to the benefits. With this we disagree. We all recognize that there are certain indirect benefits coming to every citizen of the state including the motorists, from highway improvement. This is amply taken care of through general taxation. We also know that by far the greater benefit is a benefit accruing directly to the users of the road. Is there any reason why we should be prevented from paying for that direct benefit? No one realizes the direct benefit more than the motorist, and he is invariably willing to make a reasonable payment therefor.

The motor license fee law of the state of Illinois comes nearer to applying the fundamental principle, above referred to, than any other revenue law upon the statute books of this state or any other state so far as my information goes.

I have not written this article for the purpose of trying to influence any state toward any particular policy or method in the expenditure of its motor license fees or for the purpose of urging any state to adopt the plan which we are using in Illinois. My sole object is to call attention to the well known fact that conditions in the several states differ, and to make a plea for the permission of each state, knowing its own conditions, knowing its own people, to use those fees as the judgment of the residents of the state may determine without outside interference.

If the state of New York or the state of Michigan or any other state requires all of the funds derived from motor license fees for maintenance there can be no objection; on the other hand, if the state of Alabama or Georgia or any other state wishes to use its motor license fees for road construction by a bond issue or otherwise, that is their affair. The real test is not whether the money comes from motor licence fees or general taxes; but how it is expended. If we spend it wisely and honestly the people will furnish it unstintingly.

Discounts on Invoices Pays Salaries of Clerks.—The Auditing Division of the Pennsylvania State Highway Department has announced that the discount earned on invoices paid within the cash discount period between March 1 and December 1, 1919, totaled $8,221.85, which was more than sufficient to pay the salaries of all the clerks in the invoice and purchase section of the State Highway Department. During the year 1920, permission having been granted by the Auditor General to pay invoices upon which cash discount can be earned by voucher check, the department expects to realize a sum far in excess of that earned last year by the prompt payment of its bills. All tenders of purchase, therefore, this year will carry the proviso that cash discount will be deducted from the invoice covering the purchase, if paid within 10 days from date of invoice.

Cost of Motor Truck Haulage in Road Construction

The following data on hauling with motor trucks are abstracted from a recent issue of The Commercial Car Journal:

R. H. Gumz, paving contractor in Milwaukee, paid $1.50 per cu. yd. for hauling concrete aggregates 8½ miles from the pit to the job. The trucks hauled 5 cu. yd. to the load and usually made six trips a day. The cost of hauling aggregates this distance by team would have amounted to nearly twice that price, even if teams could have been secured at $1 an hour.

During the construction of the Beloit-Janesville road in southern Wisconsin, the contractor paid for the delivery of aggregates as follows:

$1.10 per cu. yd. on a 3⅓ to 4½-mile haul;
1.00 per cu. yd. on a 3 to 3½-mile haul; and
.90 per cu. yd. on a 2 to 3-mile haul.

The Atwood-Davis Land & Gravel Co., from whom the aggregates were bought, delivered them on the job for the above prices, using three trucks, two trucks hauling 40 cu. yd. per day and one truck hauling 24 cu. yd. per day.

The following tables show the cost of hauling aggregates on a highway job in Luce county, Michigan, under construction during the summer of 1918. Two 5-ton trucks were used. The interest on truck investment was taken at 6 per cent per year, and no insurance was included:

The charges for truck No. 1 were:

Depreciation, 100,000 miles (truck value minus tires)	$ 255.16
Total wages of driver	319.74
Gasoline, 1,377 gal. at 25 ct	344.25
Lubricating oil, 117 gal. at 56 ct	65.52
Hard oil, 128.5 lb. at 6 ct	7.71
Waste, 20 lb. at 20 ct	4.00
Tire depreciation, 5,316 miles at 3 ct	159.48
Repairs and renewals	160.00
Total operating charges	$1,315.86
Fixed charges (interest)	288.00
	$1,603.86
Average haul in miles	5.54
Number of yards hauled	1,863.00
Total number yard miles performed, 10,321	$0.155 yd. mile
Total number ton miles performed, 15,481	0.104 ton mile

The charges for truck No. 2 were:

Depreciation, 100,000 miles (truck value minus tires)	$ 237.40
Total wages of driver	297.00
Gasoline, 1,235 gal. at 25 ct	308.75
Lubricating oils, 117 gal. at 65 ct	68.88
Hard oils, 128.5 lb. at 6 ct	4.08
Waste, 21.5 lb. at 20 ct	4.30
Tire depreciation at 3 ct. per mile	148.38
Repairs and renewals	131.00
Total operating charges	$1,199.79
Fixed charges (interest)	288.00
	$1,487.79
Average haul in miles	5.54
Number of yards hauled	1,780.00
Total number of yard miles performed, 9,861	$0.151 yd. mile
Total number of ton mile performed, 14,791	0.101 ton mile

The cost of hauling aggregates by motor truck for the construction of a one-course concrete road in Allen county, Indiana, was $0.011 per sq. yd. of pavement. The hauling was done with 3 and 4-ton trucks, the average length of haul being 1.7 miles. The materials were loaded mechanically at a cost of approximately 9 ct. per cubic yard, the actual cost of hauling being 42 ct. per cubic yard.

A saving of about $1,000 per mile was affected by Itasca county, Minnesota, by using motor trucks instead of teams for hauling materials on the construction of the Grand Rapids-Duluth highway in the fall of 1918. Two motor trucks of 5 cu. yd. capacity and three of 3 cu. yd. capacity were used. Figuring in all expenses for operation of trucks, and including depreciation and interest, garage charges, repairs and overhauling on completion of the work, it was found that the cost of hauling was $1.15 per yard, the average hauling being 3 miles. If the hauling had been done by teams, the cost would have been very near to $2 per cubic yard and the cost of the road would have been increased by $1,000 per mile.

During the construction of the Belair road of the Maryland State Highway Commission, in the spring of 1919, wet concrete was delivered from a central crushing and mixing plant to the road surface by motor truck over hauls ranging from ¼ to 4 miles. Extensive rehandling of materials was thus dispensed with and the cost of the work reduced. In spite of the length of the haul, there was no apparent injury to the quality of the concrete mixture. As there was excellent stone in the hills adjacent to the road, a location was selected about midway on the contract, a quarry opened and a crushing and mixing plant installed. A 3-ft. strip of concrete, 8 in. thick, was built on each side of the macadam road. The mixed concrete was dumped from the trucks upon the surface of the old road and shoveled into the forms at the side. Forty cubic yards of concrete were placed per day, the average cost of hauling being $1.76 per cubic yard.

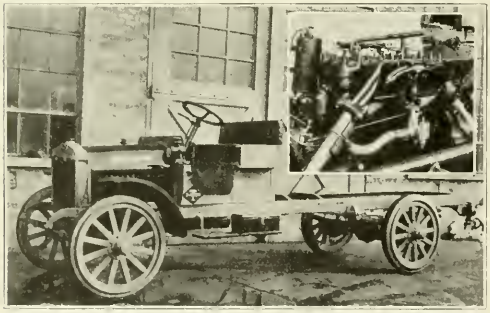
New 2-Ton Diamond T Truck

A four-speed transmission, a special "Dri-gas" intake manifold and vacuum feed system for the fuel designed to obtain best results from present low grade gasoline, forced lubrication for all spring shackles, and bearing carriers for the propeller shafts are among the features of the just announced Model U 2-ton motor truck brought out by the Diamond T Motor Car Co. Like the other Diamond T trucks, the new vehicle is worm-driven.

The four speeds give unusual low reduction in the transmission; fourth speed, 1 to 1; third speed, 1.60 to 1; second speed, 2.69 to 1; first speed, 4.75 to 1; reverse, 5.95 to 1. The transmission was designed for heavy duty under severe operating conditions and all gears are of nickel steel with wide tooth faces for carrying heavy loads.

The unit power plant is a block casting of four cylinders, 4 in. bore and 5¼ in. stroke with an S. A. E. rating of 25.6 hp. and a maximum of 43 hp. at 1,800 revolutions a minute. All the valves are on one side and have removable heads. Three point suspension with a patent-applied-for ball and socket joint as the rear motor support, is used for the engine.

Like all other Diamond T trucks, perfected Hotchkiss drive is used and radius rods are eliminated. The semi-elliptic springs are made of chrome-vanadium steel and each leaf is tested separately. The front spring has 9 leaves, 2¼ in. wide and 40 in. long. The rear spring has 12 leaves, 2½ in. wide and 53 in. long.


Chassis and Power Plant of New 2-Ton Diamond T Truck.

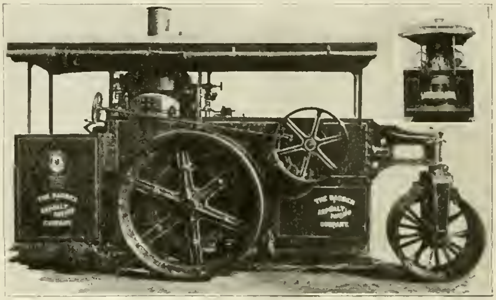
The truck weighs 4,800 lb. The tires are solid, 36 x 4 front and 36 x 7 rear. The fuel tank, with a capacity of 18 gal., is located under the seat.

Life of Motor Trucks.—An editorial in the February Power Wagon points out that records of economy, efficiency and durability of motor trucks have been accumulating rapidly with the growth in the use of machines and the increasing care given to watching their performance, and it is now possible to substantiate many of the bold assertions of former years regarding the useful life of these vehicles. One manufacturer, states the editorial, has repeatedly drawn attention to the fact that numerous machines of his make have reached a mileage of 100,000, while many others have exceeded it, some being still in service after more than 300,000 miles of economical travel. On an estimated average daily mileage of 50, which is very common in many lines of trade, this means, in the maximum case cited, a time-life of twenty 300 day years, or at least 10 years, were the daily mileage as high as 100. Even a life of but 200,000 miles indicates a time-life of 13 years and 4 months at the rate of 50 miles a day. In such a case depreciation, considered as an annual rather than as a mileage charge, is no greater than 7.5 per centum instead of the 33⅓, 25 and 20 per centum figures so frequently employed by operators.

New Design of Macadam Roller

After many years of experimental work and tests under actual working conditions, the Iroquois Department of the Barber Asphalt Paving Co. has perfected and placed on the market what is claimed to be an entirely new type of macadam road roller.

The most noticeable feature of the new Iroquois roller is the vertical boiler which rests upon the steel framework of the roller itself, a separate unit to which nothing is bolted. The boiler may be easily removed for repairs without disturbing any other part of the roller. It is stated to have over 50 per cent more heating surface than in the old type roller.

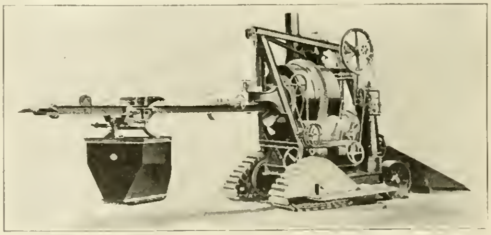

New Iroquois Macadam Roller.

The engine also is a separate unit and rests upon the roller framework, on a three point suspension that has demonstrated its many advantages in automobile construction. The drive is accomplished through a differential gear to the rear wheels. This may be locked out for hard straight pulls. Positive steer is assured through a steel quadrant that prohibits the front roll dragging and shoving up the surface of the highway. The rear wheels are equipped with demountable rims, easily renewed when worn.

A steam scarifier is part of the standard equipment. It is adjustable, scarifying any depth desired the full width of the roller, in the hardest kind of material.

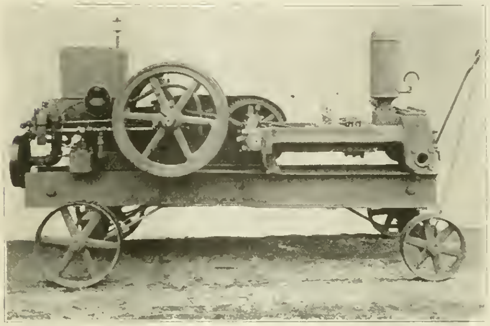
1920 Model Smith Simplex Paving Mixer

Simplicity in design, construction and operation are the outstanding features of the new 1920 model of Simplex paver of the T. L. Smith Co. The machine has been designed with a view to reducing breakdowns to a minimum. Strength has been added to the vital sections and fewer working parts are incorporated into its construction. As an example, only 11 gears are used throughout the entire paver. The entire operation of the machine is controlled by four levers and four control wheels, all located within easy reach of a man standing on the operator's platform. Another feature is that of convertibility. It is possible to use the paver with either a boom-and-bucket or a chute delivery. The frame is so constructed as to accommodate either equipment and the change can be made quickly—right on the job if necessary. The traction may be the wheel or the caterpillar type.


1920 Model Smith Simplex Paver.

Portable High Pressure Pumping Outfit for Road Builders

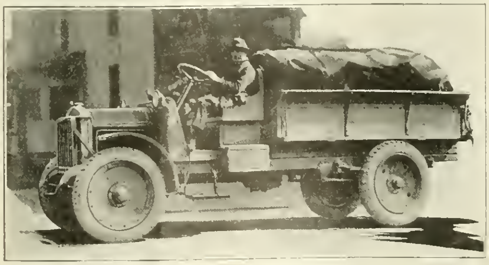
A high pressure, horizontal, triplex pumping unit, specially designed to meet the conditions met in road construction operations, has been placed on the market by the Domestic Engine & Pump Co., Shippensburg, Pa. The units are built for hard and constant duty and for pressures up to and including 300 lb. per square inch. It is claimed that the outfit will handle water containing a small percentage of sand or grit without damage to the pump. The plungers do not come in contact with the metal of the cylinders, being held in alignment by a very liberal cross head and working back and forth through stationary rings of waterproof hydraulic packing placed in easily accessible stuffing boxes. The pinion gear on the engine is engaged or disengaged by a friction clutch of liberal friction area. This permits the starting of engine without load and then when engine is up to speed the starting up of the pump gradually even against full load. The outfit is mounted on an all metal low-wheel, broad face tire truck, which makes unnecessary any other foundation for field installations. The unit is made in three sizes: 40 gal. capacity per minute and total work head of 500 ft.; 50 gal. capacity per minute and total work head of 380 ft.; and 50 gal. capacity per minute and total work head of 575 ft.



New "Domestic" Road Builders' Pumping Unit.

A New 1-Ton Truck

The Federal Motor Truck Co. has added a new 1-ton truck to its line. The new truck, shown for the first time in New York and Chicago National Truck Shows, is built strictly in accordance with Federal standards of real hard duty service. The essential features worked out are: a governor control speed of 25 miles per hour; pneumatic cord tires; pressed steel frames; disc steel wheels; heavy support radius rods; electrical lighting equipment lamps on swivels which can be turned to point where light is needed most; special hard service battery and generator; thoroughly proven power tire pump; steel seat and dash. The truck has all the sturdy lines of the larger Federals with the additional feature of speed. It is a heavy duty truck for light loads.



New Federal 1-Ton Truck.

Device for Spreading Loose Material

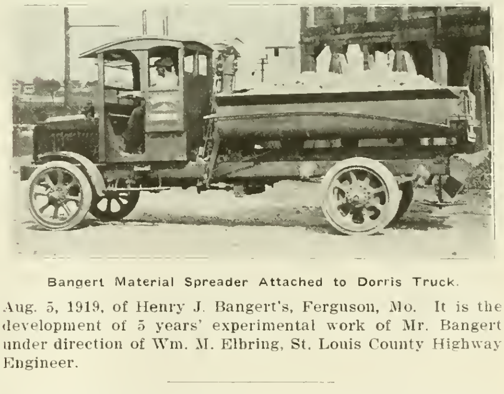
A device for spreading sand or gravel has been developed by Mr. Henry J. Bangert, of Ferguson, Mo. The illustration shows the spreader as used with a standard Doris 3½-ton truck chassis and a Woods hydraulic hoist on a 4 yd. body. The spreader proper is a 26 in. circular disc, dished to hold the material to the center until it has filled up sufficiently to reach the cleats bolted on the disc which insures an even distribution of material. This disc is driven by a set of bevel gears at the rear end of the truck. A silent chain drive delivers the power from the auxiliary power takeoff of the transmission to the horizontal shaft of the spreader.

A hopper on the back end of the truck frame has a lid on it which is so hinged that it will close when the entire load of material is to be dumped out of the rear end of the body. This lid, when opened forms an opening which receives material to be spread and delivers it on the center of the revolving disc. A 24 in. by 6 in. adjustable sliding opening in rear end of body regulates the feed of material out of the body when same is elevated.

The control of body height, truck speed, disc speed, and opening sliding gate gives any distribution from 8 ft. to 30 ft. in width and a 1/32 in. to 1 in. thickness. It is claimed that any loose material from sand to ⅞ in. gravel can be handled

One of the advantages of the present equipment is that the truck and dump body can be the same as an ordinary dump truck when there is no spreading to be done, thus keeping the equipment busy all the time.

The spreader was built under Patent No. 1,312,226, dated Aug. 5, 1919, of Henry J. Bangert's, Ferguson, Mo. It is the development of 5 years' experimental work of Mr. Bangert under direction of Wm. M. Elbring, St. Louis County Highway Engineer.



Bangert Material Spreader Attached to Dorris Truck.

State Highway Construction in Pennsylvania.—During 1919 the State Highway Department of Pennsylvania completed the construction of 253.1 miles of durable highway and 41.58 miles of uncovered base. During 1919 the State Highway Department contracted for the construction of 685.02 miles of durable roadway of various types. Contracts carried over from 1918 into 1919 totaled 95.47 miles. During 1919, 73.36 miles of the uncompleted 1918 mileage was finished and there remains to be done 22.11 miles. Of the 685.02 miles contracted for in 1919, 179.74 miles were entirely completed when contractors were compelled to shut down for the winter. The 1920 season will start with contractors at work on 527.39 miles of contract remaining from 1919 and 1918. The department before April 1 will have opened bids for the construction of approximately 800 additional miles of roadway so that by July 1 it is estimated that work will be under way on approximately 1,300 miles of new roads. The unusually rainy weather greatly interfered with the work of contractors during all of 1919. There was an average of 127 days of rain during the year in Pennsylvania. This meant that not only was the work of the contractor interfered with on the day of rain, but on subsequent days until the subgrade dried sufficiently to permit operations to resume.

The Steam Shovel in Snow Removal Work

Steam shovels gave effective service in several eastern cities in removing the snow due to the heavy blizzards of last month. In Springfield, Mass., Keystone traction steam shovels, used on snow removal work, were run in 12-hour shifts right through the 24 hours. The same type shovel also was used in New York City. In the latter city the Anorac Engineering & Contracting Corp., which with other organizations was impressed into the service of the city in its snow removal emergency, moved its Keystone grader from an uptown excavation job to the business district and placed it at work loading snow into trucks. The first day it was impossible to get an adequate supply of fuel for the grader, the hauling conditions were so bad. It also was impossible to keep the grader supplied with trucks fast enough to keep it busy, so that the first day it was idle about half the time, but nevertheless removed about 272 yd. (city measurement) of snow. Traveling conditions did not improve the second day and while the number of trucks was increased, the grader still was not working to capacity. As the snow was gradually removed and hauling conditions improved, the output of the grader was correspondingly increased, until February 14th, when a maximum output of 439 yds. (city measurement) was reached.

Digging Out Broadway, New York City, With a Steam Shovel.

It should be stated here that the measurement by the city of trucks for the snow removal, allowed what is called a heap measurement of 6 ft. over the top area of the truck. Most of the trucks have been filled at least 2 ft. over the top area, for which no allowance is made in this measurement by the city.

The contractors consider that the grader took the place of at least 50 laborers during this entire work for snow removal, even considering the time lost through unforeseen difficulties.

Predicts 10,000,000 Motor Vehicles in U. S. by End of 1920. Statisticians of the B. F. Goodrich Rubber Co. predict that there will be at least 10,000,000 motor vehicles in service in this country by the end of this present year. Following is a list of the registrations by states for the last two years, and the percentage.

States	1918.	1919.	Pctg. of increase.
Alabama	46,155	62,000	34.3
Arizona	23,875	29,000	21.5
Arkansas	41,458	49,450	19.3
California	337,878	441,101	30.6
Colorado	80,000	112,135	40.2
Connecticut	84,902	105,419	24.2
Delaware	12,955	15,006	15.8
Florida	47,059	58,263	23.8
Georgia	99,160	134,926	36.0
Idaho	32,282	46,852	45.1
Illinois	389,135	478,450	23.0
Indiana	227,160	277,255	22.1
Iowa	285,000	362,000	27.0
Kansas	189,592	228,326	20.4
Kentucky	65,884	87,764	33.2
Louisiana	39,760	50,000	25.8
Massachusetts	193,497	250,800	29.6
Michigan	261,527	346,218	32.4
Maine	44,572	51,334	15.2
Maryland	78,146	104,353	33.5
Mississippi	40,000	48,000	20.0
Missouri	187,646	244,167	30.1
Minnesota	203,727	258,719	27.0
Montana	51,050	59,300	16.2
Nebraska	175,370	197,300	12.5
New Hampshire	24,904	30,006	20.5
New Jersey	154,870	192,000	24.0
New Mexico	16,893	23,030	36.3
Nevada	8,160	9,305	14.0
North Dakota	71,687	72,885	1.7
New York	457,924	600,000	31.0
North Carolina	72,300	106,125	46.8
Ohio	417,400	511,500	22.5
Oklahoma	120,800	151,300	25.8
Oregon	66,607	79,762	19.8
Pennsylvania	393,972	414,485	5.2
Rhode Island	30,595	42,000	37.3
South Carolina	55,400	67,981	22.7
South Dakota	86,121	102,701	19.3
Tennessee	65,000	80,500	23.8
Texas	250,201	330,100	31.9
Utah	27,204	35,144	29.2
Virginia	72,228	94,100	30.3
Vermont	22,550	26,806	18.9
Washington	119,905	177,566	48.1
West Virginia	38,600	50,203	30.1
Wisconsin	196,844	238,360	21.1
Wyoming	16,150	21,372	32.3
	6,023,605	7,555,269	26.0

Personals

Gus Otter has been appointed county engineer of Ashland county, Ohio.

Charles S. Carroll has resigned as professor of civil engineering at the University of Cincinnati.

B. F. Umland, formerly state highway engineer for Clearwater county, Minnesota, has been appointed to fill a similar position in Pennsylvania county, succeeding Glenn Martz.

T. S. Brindle, formerly county surveyor of Ashland county, O., has been appointed chief engineer of the Ohio State Highway Department, to succeed H. D. Bruning, who resigned recently.

J. Harry Gross, for 24 years city park engineer of Baltimore, Md., has resigned to become engineer and manager of the power apparatus department of the Baltimore Electric Supply Co., Winfield F. Courts succeeds Mr. Gross as park engineer.

Colonel George A. Johnson, Utilities Division, Construction Division of the Army, has resigned his commission, and will be discharged from the service on March 1st. Some time ago the announcement was made in this column of the formation of the firm of Johnson & Benham, with offices at 150 Nassau street, New York City, and Firestone Bldg., Kansas City, Mo. Colonel Johnson will hereafter be the directing head of this firm whose affairs up to now have been managed by Major Webster L. Benham. The firm specializes on water supply, sewerage and public utilities in general, from standpoints of design, supervision of construction and management.

Industrial Notes

The Dayton-Dowd Co., Quincy, Ill., has opened a branch office in Cleveland, O., under the management of L. E. Maher of the Maher Engineering Co., of Chicago. The office will handle the line of Dayton-Dowd centrifugal pumps in addition to other mechanical equipments.

Captain P. C. Painter, late of the Engineering Corps of the United States Army and former Senior Highway Engineer of the U. S. Bureau of Public Roads, has been appointed District Engineer of the Eastern District of the Eastern Paving Brick Manufacturers' Association with headquarters at Philadelphia.

The United States Circuit Court of Appeals for the First Circuit has affirmed the decision of the District Court for the District of Massachusetts in the cause, Cressy Contracting Co. vs. Independent Coal Tar Co., Boston, and found United States letters patent No. 1,062,029 for apparatus for spraying oil on road surfaces, valid and infringed. This cause has been pending since March, 1916, and has been vigorously prosecuted by both sides. A like suit was also brought at the same time against Michael McDonough of Swampscott, Mass., who was also found to have infringed the patent. This decision gives the Cressy Contracting Co., owner of the Pillsbury patent, the sole right to make and sell or use the patented spraying construction, generally known as the Pillsbury sprayer, whether operated by steam or compressed air.

The Asphalt Association, an organization representing producers and users of asphalt for paving purposes, has established permanent headquarters in the new National Association building, 25 West 43rd street, New York City. J. R. Draney of the United States Asphalt Refining Co. is president of the association; W. W. McFarland of the Warner-Quinlan Co. is vice-president; Herbert Spencer of the Standard Oil Co. of New Jersey is treasurer, and J. E. Pennypacker; formerly chief of management of the United States Bureau of Public Roads, secretary. A feature of the association's activities is a brochure series explaining the approved methods of constructing asphalt pavements, including asphalt macadam, asphalt concrete and sheet asphalt pavements and presenting information as to asphalt specifications, the use of asphalt fillers for brick and block pavements. Lectures in universities and colleges have been given, or arranged for, in about 25 of the leading educational institutions of the United States and Canada.

The National Distributors' Association of Construction Equipment has been formed for the purpose of promoting and maintaining a co-operative spirit between the legitimate distributors of construction equipment and their source of supply; to disseminate information among its members that will assist them in building their business on a broader scale and to exchange ideas of service for the benefit of the actual users of construction equipment. The Executive Committee consists of: J. S. Beckwith, of Beckwith Machinery Co., Pittsburgh; C. J. Borchert, of Borchert-Ingersoll Co., St. Paul; R. E. Brandeis, of Brandeis Machinery Co., Louisville; H. G. Ferris, of Hoflus-Ferris Co., Spokane; M. R. Hunter, of Kern-Hunter Co., Milwaukee; H. C. Legg, of Landes & Co., Salt Lake City; W. B. Louer, of W. B. Louer Co., Chicago; C. E. McCombe, of Pattison Supply Co., Cleveland; K. B. Noble, of Hartford Contractors' Supply Co., Hartford; Geo. Smith, of Geo. F. Smith Co., St. Louis; F. W. Swanson, of Globe Machy. Co., Des Moines.

Waterworks and Hydraulics Monthly Issue

ENGINEERING AND CONTRACTING

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Roads and Streets—1st Wednesday
(a) Roads (c) Street Cleaning
(b) Streets (d) Municipal Miscellanies
(e) Management and Office System

Waterworks and Hydraulics—2nd Wednesday
(a) Waterworks (c) Irrigation and Drainage
(b) Sewers and Sanitation (d) Power and Pumping
(e) Management and Office System

Railways and Excavation—3rd Wednesday
(a) Excavation (c) Quarries and Pits
(b) Management and Office System (d) Steam Railways, Construction and Maintenance
(e) Electric Railway Construction and Maintenance

Buildings and Structures—4th Wednesday
(a) Buildings (d) Miscellaneous Structures
(b) Bridges (e) Properties of Materials
(c) Harbor Structures (f) Management and Office System

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Volume LIII. CHICAGO, ILL., MARCH 10, 1920. Number 10.

A Field for Engineers as Statisticians

The best known statistician in America is Roger Babson. It is not generally known, even among engineers, that Mr. Babson is an engineer, a graduate of the Massachusetts Institute of Technology.

In the employ of all large railway and public utility companies, and of many industrial corporations and banks, there are thousands of men whose main function it is to compile and analyze statistical data. At first sight it may seem that the work of these professional statisticians can be as well done by accountants as by engineers, but we are of the opinion that an engineer has a marked advantage over an accountant. Most statisticians have been recruited from accounting departments, and their limitations are those necessarily inherent in a profession that is concerned primarily with "figures" and only incidentally with their application.

Engineers are also trained to gather "figures," but always with a definite end in view, namely, for the purpose of solving economic problems. This distinction is important, for thorough knowledge of what data should be secured is had only by men accustomed to using the data in solving problems.

Professors of political economy usually show the defects in their training when they begin to apply statistical data to a specific problem. For instance, they are almost invariably given to regarding a given word as if it invariably means the same thing. Thus, one political economist has recently made a serious error in estimating the efficiency of agricultural workers at different periods, because he thought the expression "total value of agricultural products" meant the very same thing in every one of the U. S. census reports. In another place he errs by using an arithmetical average of the freight rates charged by different railways, instead of using a weighted average. The arithmetical average for the year 1870 was 3.02 ct. per ton-mile, which he compares with a weighted average of 0.72 ct. for 1900, whence he erroneously concludes that freight rates in 1900 were only 24 per cent as high as in 1870.

Errors of this type are characteristic of men not well versed in the meanings of technical terms and in the derivation of the data that they attempt to apply.

Engineers experienced in appraisal and rate cases know that accountants rarely analyze and interpret all the data correctly. This holds true even when the accountants are highly skilled as accountants. Thus, if there is a problem of pro-rating the investment in a plant among the different uses to which the plant is put, an accountant will ordinarily look up some one book on accounting, and adopt the rule there given for prorating. An engineer, on the other hand, will usu-

28 Pages=40 pages

The 28 pages of articles in Engineering and Contracting contain as many words as 40 pages of the size and typography commonly used by other engineering periodicals. Ours is the same size of type and type-page as that of The Literary Digest—easily read, yet giving a large volume of reading matter per page. Our 28 pages of articles would fill 112 pages of the standard 6x9 in. text-book. It would take 10 such books of 580 pages each to hold all the articles printed each year in Engineering and Contracting, to say nothing of our weekly construction news.

ally study many authorities before deciding what method of pro-rating to adopt. His scientific training will lead him to demand a logical demonstration of the correctness of a given rule before he will accept it.

The accountants of the Post Office Department have been pro-rating joint costs according to a rule whose only merit is its simplicity. It is demonstrably illogical, and it leads to enormous errors in estimating the cost of handling and delivering the different classes of mail. But, oblivious of the fact that engineers have written scores of articles on methods of pro-rating joint costs, the accountants of the P. O. Department apparently have not looked outside the covers of Dixie's ancient work on accountancy.

There is really great need of engineering services in the interpretation of statistical data. Nor should it be difficult to convince the business managers that this is so. Already engineers almost monopolize the field of appraisals and rate making, in so far as expert testimony is concerned. Ten or fifteen years ago engineers were rarely asked to testify as to public utility rates. Their testimony was then confined to appraisals. But their ability as cost analysts and interpreters of statistics soon enabled them to displace so-called "rate experts" and accountants. In like manner, and for the same reasons, we look to see engineers gradually usurp leadership in other branches of applied statistics.

To engineers who wish to broaden their knowledge of quantitative thinking we commend "An Introduction to Statistical Methods," by Secrist, published by The Macmillan Co., New York.

Have Americans Suddenly Become Extravagant?

There is much outcry over the supposedly sudden turn toward extravagance in America, but no convincing data have been offered in evidence of this alleged fact. As a matter of fact, Americans always have been extravagant, as can be readily shown. They are spending nearly their entire earnings now, it is true, but they have never done any differently, even in the "good old days" of alleged thriftiness.

There are two admirable tests of the degree of thriftiness of any people; first, the increase in national wealth; second, the increase in savings bank deposits. But in applying these tests, it is essential to consider the relative purchasing power of the dollar.

It so happens that in 1880 and in 1910, the average prices of commodities were practically the same. Hence we can correctly compare wealth and income in 1880 with wealth and income in 1910. In 1880 there were 50 million people in America, and the aggregate wealth was 44 billion dollars, or $880 per capita, according to the U. S. Census. In 1910 there were 92 million people and their wealth was 188 billion dollars, or $2,046 per capita. Looked at in this way, these figures seem to indicate a high degree of thrift, but let us view them from another angle. How much wealth did the American people accumulate annually per capita during that 30-year period?

The increase in per capita wealth between 1880 and 1910 was $1,160, or nearly $39 per capita per annum. Since about 40 per cent of the population are engaged in gainful occupations, it follows that each of these must have averaged an increase of wealth amounting to $100 a year during that period.

In King's "Wealth and Income of the People of the United States," p. 138, we find the estimated total income in 1910 to have been 30.5 billion dollars, after excluding duplications such as the cost of raw materials and supplies in manufacturing, but including interest charges and profits. Since there were 38 million people engaged in gainful occupations in 1910, the average income due to each "worker" was $800, inclusive of interest and profits. Since wealth was increased $100 a year during the 30 years, this would seemingly indicate a saving of one-eighth of the average annual income, but two corrections must be made. First, a part of the 144 billion dollar increase in wealth during the 30-year period is ascribable to rise in land values, or "unearned increment" in value. King (p. 262) estimates the value of all land (except for city and village residences) in 1880 at about 16 billion dollars, and in 1910 at 67 billion dollars, or an increment of 51 billion dollars, which is nearly 36 per cent of the total increase of wealth during the 30-year period. Although it is true that during this period the total acreage of farm land increased 60 per cent, and that a large amount of labor was expended in clearing trees and brush, draining, etc., still it is obvious that only a part of the increment in farm land value has been due to expenditure of labor upon it. Even to a less degree is the increment in value of other lands due to labor upon it. The value of farm lands averaged only 45 per cent of the value of all lands (other than residential) during this 30-year period, and if we allow that half the increment in value of farm lands was due to labor expended upon those lands, there would remain an unearned increment of about 40 billion dollars in all land values (exclusive of residential land), or 28 per cent of the 144 billions of increased wealth during the 30-year period.

The second corrective factor is the increasing earnings during the 30-year period. In a later article we will show that this doubled during the 50-year period of 1860 to 1910, after making due allowance for variations in the purchasing power of a dollar. Hence at the middle of the 30-year period under consideration, or in 1885, income per capita was about $600 per person engaged in gainful occupation, or 25 per cent less than in 1910. This 25 per cent less income almost exactly offsets the 28 per cent increase in unearned increment in land value. Hence our original conclusion that about one-eighth of the average annual income of the American people was saved during the period of 1880 to 1910 is at least a liberal estimate. That it is too high an estimate, and should be reduced to about one-tenth of the annual income, seems evident from the fact that we have ignored the unearned increment in residence land values. Also, it should be remembered that we have made a very liberal allowance for the effect of labor on farm land in enhancing its value.

Let us now turn to the evidence of thriftiness as disclosed by increments in savings bank deposits. In 1880 the total savings banks deposits were $16.40 per capita, and in 1910 they had risen to $44.20. Hence savings deposits had increased about 90 ct. per capita per annum for 30 years. This is not a very startling evidence of thrift among the masses of the American people. It is equivalent to the savings of about six weeks' wages during 1,560 weeks, or less than half of one per cent of the total wages received during 30 years.

The total savings deposits rose from 3,018 millions on July 1, 1913, to 6,114 millions on July 1, 1918. At first sight this looks like a very great sudden accession to thrift, for its amounts to an increment of $30 per capita in 5 years, or $6 per year; but it is largely offset by the increment in prices, and the corresponding shrinkage of the value of a dollar. Average prices for 1913 were 100, as compared with 197 for 1918. Hence we must decrease the savings deposits of 1918 by 50 per cent to get back to the level of purchasing power in 1913. If we do this, the 3,096 million dollars of savings deposit increase between 1913 and 1918 shrinks to 1,548 millions, which represents a per capita increase over 1913 of $14, or at the rate of $2.80 per capita per annum. This is three times the average annual increment in savings deposits during the period of 1880 to 1910, but it is a pitifully small gain. At any rate it is a real improvement in thrift, and its serves to show how erroneous are the statements that present high prices are due to a waning of the thrift habit among the masses of people. The fact is that there has never been a thrift habit among the masses. Due to Liberty Loan propaganda and the like, there has been more thrift on the part of the masses during the last few years than ever before; but the habits of a lifetime are not quickly changed to great degree.

Prof. King estimates that about 25 per cent of the entire annual income of the American people comes from interest and dividends on investments. This 25 per cent goes mainly to thrifty people, and therefore to the small minority. From this small minority (probably less than 25 per cent of the entire population) comes practically all the new capital that is annually invested in the wealth that the Census Bureau reports. If this minority were to save 40 per cent of its income from dividends and interest, that saving would provide for the entire 10 per cent of annual increment in tangible wealth.

Since the present income taxes are taking away from the thrifty minority most of the income that they would normally invest, it is easy to understand why new issues of stocks and bonds find such a poor market, and consequently why interest rates have risen so greatly and are still rising. The new bonds of large utility and industrial companies are daily offered for sale at rates that net the investor 6 to 7 per cent. These are the kind of bonds that a few years ago were marketed at prices that yielded 4.5 to 5.5 per cent.

Although the thriftlessness of the great majority of the people accounts for the present bad condition of the market for scurities, this thriftlessness does not account for present high prices. Even assuming that the normal saving of 10 per cent of the total income were completely wiped out, the effect of this could not be to raise average prices more than 10 per cent. Wholesale prices averaged 230 in Nov., 1919, as compared with 101 for Oct., 1913. Clearly, then increased spendthriftness has had very little to do with this great increase in prices. The major factor in raising prices has been the enormous increase in currency since 1913.

Will You Be the Leader?

The per worker output of American farmers has not increased half as rapidly in the past 50 years as has the per worker output of American factory hands and miners. Farmers have increased their output per farmer at the rate of only 1 per cent per annum since 1870, whereas the corresponding increase in efficiency of factory workers and miners has been 2.5 per cent per annum per worker. Yet Burbank states that science applied in agriculture is as effective as science applied in manufacturing, in respect of the gain in economic efficiency. If so, the plain inference is that farmers are not availing themselves of even a small fraction of the knowledge that such men as Burbank possess.

Civil engineers know how to drain and to irrigate the lands of the Mississippi Valley, and thus double the present crops. But their services are not in demand for this purpose, except to an inconsiderable extent. The blame may be laid at the door of the farmers; that is, at the door of ignorance. But is it not more just to lay the blame at the door of the engineers, the door of knowledge?

If the civil engineers of the Mississippi Valley were to engage in propaganda for extensive under drainage and for irrigation by pumping, there is no doubt that they could bring about a revolutionary increase in crops, and coincidently banish crop failures. The question, however, arises as to who will furnish money for such a publicity campaign. Furthermore, how would the promoters of the enterprise secure their reward? These are practical questions of great importance, but are they beyond the power of engineers to answer satisfactorily?

Civil engineers are mainly engaged in public work, or in work of a quasi-public nature. The public, as a rule, spends little for publicity. It does not even advertise its own best product—education. Hence it seems almost hopeless to try to persuade public officials to assist in a campaign to promote anything, even though it be demonstrable that the public itself would be greatly the gainer.

Who should be credited with the great road building program now under way? Certainly not the farmers. The credit belongs mainly to the manufacturers of motor vehicles. Civil engineers, it is true, have been factors in arousing public interest in roads, and they have aided in preparing better laws for highway improvement. Yet, without the aid of automobile manufacturers we fear that civil engineers would have accomplished relatively little in securing large highway appropriations.

Is it feasible, in a similar manner, to enlist the support of manufacturers in an effort to sub-drain and irrigate the humid lands of America? The thought merits contemplation. Billions of dollars could be profitably invested in drain tile, in pumps, in water pipe, and in construction equipment. Thousands of civil engineers and contractors could be profitably employed for many years on land improvement. But at present no one is campaigning for this improvement. No one of sufficiently broad vision and persuasive powers has undertaken to make himself leader of an enterprise that is second to none in economic possibilities.

Book Reviews

Manual of Gurley Hydraulic Engineering Instruments.—Compiled by W. and L. E. Gurley, Makers, Troy, N. Y. Flexible cloth, 6x9 in., 140 pp., illustrated.

This trade manual is essentially a hydrographic survey handbook. Part I describes the construction, care and use of current meters, and Part II gives the construction, installation and operation of automatic water stage registers.

The current meter is described in detail, the several different classes are noted, and suggestions are given as to care in the selection of the proper type. Instructions for rating the meter are specific, and a reduction table of ratings is appended. The three classes of current meter measurements in common use, namely: wading, cable and bridge measurements, are taken up separately. Methods for making soundings, velocity observations, tabulating the data, low water and under ice measurements are included. A good deal of space is given to advice as to the selection and location of gaging stations.

Part II enumerates the conditions under which the automatic water stage register is required, gives its essential features, and describes the two different types. Many examples of installations and shelters are illustrated.

The volume contains much specific information and there is careful attention given to details which would aid in the most intelligent use of the instruments described.

Is a New Organization Necessary to Further Non-Technical Interest of Engineers?

To the Editor: In your issue of Feb. 11, 1920, is a letter by C. E. Drayer, Secretary of the American Association of Engineers, entitled, "Is a new organization necessary to further non-technical interest of engineers?" This question, in substance, among others, is now before the American Society of Civil Engineers in the form of a questionnaire. Shall the society actively co-operate with other engineering and allied technical societies in the creation of a new organization for the purpose above set forth? As a member of this society I do not think it desirable to form such a new organization, and am inclined toward the plan as set forth by Secretary Drayer in his letter to the governing bodies of the founder societies.

The American Association of Engineers is a going concern already and is working for the welfare of the engineer of all grades, and if the founder societies elect to co-operate with this society in the work it is doing, no financial aid would be expected. The formation of a new organization to duplicate the work and aims of the A. A. E. does not appear advisable to the writer from any point of view.

The rank and file of the engineering profession have been waiting for years for just such a movement as that inaugurated by the A. A. E. for the social and economic welfare of the engineers. In unity there is strength and I am in favor of unity along the lines as expressed in Secretary Drayer's letter to the governing bodies of the founder societies. I heartily endorse the idea of developing and broadening the functions of the present Engineering Council to make it more representative, but am opposed to a new and somewhat unrestricted organization as proposed by the joint conference committees' report of the founder societies.

St. Maries, Idaho. M. J. PARKER.

Water Purification at Pittsburgh, Pa.—Valuing a life at $3000 and the cost of a case of typhoid fever at $300, Chester F. Drake, engineer in charge of the Pittsburgh filtration plant, according to a press dispatch, estimates that the plant pays for itself every 18 months. Before the city had filtered water the death rate from typhoid fever was approximately 130 per 100,000 of population every year. Last year it was approximately four per 100,000 of population.

$20,000,000 Power Project in Greece.—Ford, Bacon & Davis Construction Co., New York City, is reported to have started engineering investigations for a $20,000,000 power project near Athens, Greece.

Storm Water Sewer Construction at Hamilton, O.

As a part of the local flood protection work at Hamilton, O., the Miami Conservancy District has recently completed three storm water sewers. The sewers were constructed of concrete, were 4 ft. to 5 ft. 8 in. in size and had a total length of 4,160 ft. They were located in Buckeye St., in Wood St. and in Front St. The work is described by Mr. R. B. McWhorter, Assistant Division Engineer of the District, in The Miami Conservancy Bulletin, from which the matter following is taken:

General Features of Buckeye St. Sewer.—There is an area in the northeast part of the city from which the storm sewers drain into the tail-race, which, until recently, flowed northerly to Old River. This tail-race was a part of the Hamilton and Rossville hydraulic and was abandoned for power use with the other parts inside the corporation limits. Its outlet was closed by the Old River improvement, and the sewers that empty into it are now served by the Buckeye St. intercepting sewer, which connects with the tail-race. The maximum flood stage to be expected at Buckeye St. is elevation 589.5 ft., or about 3.5 ft. lower than at the tail-race outlet, a noteworthy advantage of the new location.

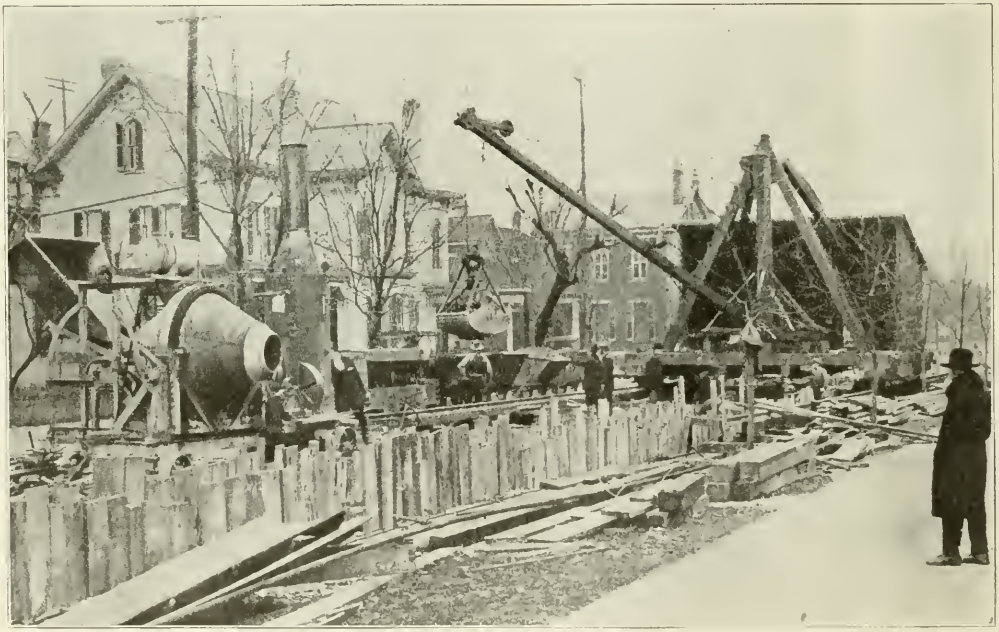


Fig. 1—Equipment Used In Constructing Buckeye Street Storm Water Sewer at Hamilton, Ohio.

A ½-yard Smith concrete mixer, portable electric derrick with ¾-yard clamshell bucket, a 3-ton Plymouth gasoline locomotive and four 1½-yard side dump cars.

This sewer is made of reinforced concrete, horseshoe shaped, inside dimensions 5 ft. x 5 ft. 8 in. and is 1,868 ft. long. A cross-section of the sewer and design of forms in detail is shown in Fig. 2. It connects with the tail-race 300 ft. east of 4th St. and runs westerly, 9 ft. north of the south curb, to the river. The elevation of the flowline at the connection with the tail-race is 577.0 ft. There is a change in grade at 3rd St., 740 ft. from the tail-race. Above this point the grade is 0.45 per cent and below it 0.40 per cent. The sewer has an inside sectional area of 24.5 sq. ft., and is capable of discharging about 200 cu. ft. per second. There is a gate manhole about 70 ft. back from the outlet, in which a floodgate will be operated during extreme flood stages. A standard manhole was provided at each street intersection, through which there can be no overflow, even with the floodgate out of commission, as the street surface is from 6 in. to 6 ft. above the maximum flood level. The gate will protect the ground surface from flooding should the river level approach the top of levee, which at Buckeye St. is 4 ft. above the estimated maximum flood level.

Excavation Methods.—The excavation was begun at the lower end of the trench, the plant used consisting of an electrically operated traveling derrick, fitted with a ¾-yd. clamshell bucket, and mounted on a 28 ft. gage track, straddling the ditch; one 24 in. gage Plymouth gasoline locomotive, four 1½ yd. rocker dump cars, and 420 ft. of track laid with 30-lb. rail. The track was placed alongside the ditch at a convenient distance for the derrick to load the cars. The amount of material by which the excavation exceeded the backfill was wasted on the river bank south of the outlet to be later removed by the large river excavating machine. The depth of cut ranged from 14 to 24 ft.

A stratum of hard, tough, blue clay, varying in thickness from 4 to 7 ft., and lying from 8 to 10 ft. below the surface, was found, extending from the outlet to a point some 450 ft. up the trench. This material was difficult to remove and empeded the progress, increasing the expense considerably during the first month or so. Dynamite was used, but not very effectively. The clay proved to be too soft to blast and too hard to be handled satisfactorily by the clamshell. West of Front St. the material other than the clay consisted of cinders and loam. From Front St. to 4th St. 3 or 4 ft. of surface loam was underlaid by clean gravel and sand, suitable for use in concrete.

Because of the nature of the soil and the depth of the trench continuous sheathing of the sides was necessary. Fig. 3 shows the method of shoring the trench.

A street railway line runs up 3rd St. to Black St., under which the sewer trench was passed, thereby necessitating an interruption of the service north of 3rd St. As the patronage on that part of the line is small, except during the early morning and late afternoon hours, the daytime service was suspended for the few days the derrick was working over the track. Provision was made to pass the cars up to 8 a. m. and after 4 p. m.

The double track main line of the Baltimore & Ohio R. R. crosses Buckeye St. at 4th St., and the sewer was carried under these tracks by means of a tunnel. The tunnel was 48 ft. long, of cap and leg construction, sheated overhead and on the sides. The sections shown in Fig. 4 give an idea of the manner in which the tunnel was built. To guard against possible settlement of the tracks four 8 in. x 16 in. stringers, 30 ft. long, were placed by the railroad company symmetrically under each rail, each resting on four 16 in. square mudsills, one placed on either side of the trench and one at either end of the stringers. After completing the sewer through the tunnel the remaining space was packed full of loam sand, care being taken to leave no voids. The temporary timbers under the tracks were then removed, and the original condition restored.

Concrete Construction Methods.—A ½ yd. Smith portable tilting mixer and wood chutes were used for mixing and placing the concrete. The "trench run" material supplied both the fine and coarse aggregates, as frequent screening tests made throughout the work indicated that no screening was necessary. These tests, through ¼-in. screens, showed the ratio of gravel to sand, with only one exception, to range from 2½:1 to 2:1. Sufficient cement, as determined from the tests was used to maintain a ratio of 1:2 between cement and sand, and enough water was used to make a mix that would move down the chutes with slight assistance from a hoe or shovel. Both water and aggregates were heated during freezing weather, and the fresh work was covered with tarpaulins under which salamanders were placed. However, the winter of 1918-19 was very mild, and heating was necessary in only a few instances. A layer of tar paper prevented the concrete from coming in contact with the sheeting.

Figure 2 shows in detail the forms used, and the methods employed to hold them in place. It also shows the sequence of the concreting operations. Forms were left in place till the second day after concrete was placed, usually from 40 to 48 hours.

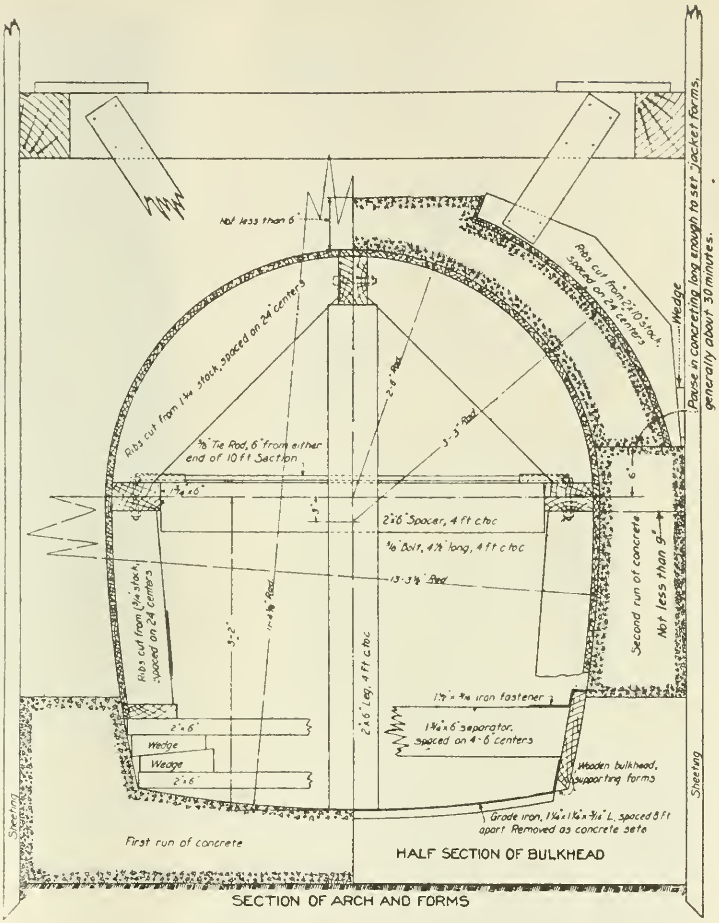

Not less than 6"
Ribs cut from 1¾ stock, spaced on 24" centers
⅜" Tie Rod, 6" from either end of 10 ft Section
1¾x6"
3"
2'-6" Rad.
3'-3" Rad.
Ribs cut from 2"x10" stock, spaced on 24" centers
Wedge
Pause in concreting long enough to set "jacket" forms, generally about 30 minutes.
6"
2"x6" Spacer, 4 ft c to c
⅜" Bolt, 4½" long, 4 ft c to c
13'-3½" Rad.
Ribs cut from 1¾ stock, spaced on 24" centers
3'-2"
11'-4½" Rad.
2"x6" Leg, 4 ft c to c
Second run of concrete
Not less than 9"
1½" x ⅜" iron fastener
1¾"x6" separator, spaced on 4'-6" centers
2"x6"
Wedge
Wedge
2"x6"
Wooden bulkhead, supporting forms
Sheeting
Sheeting
Grade iron, 1¼"x1¼"x³⁄₁₆" L, spaced 8 ft apart Removed as concrete sets
First run of concrete
HALF SECTION OF BULKHEAD
SECTION OF ARCH AND FORMS

Fig. 2—Section of Buckeye Street Storm Water Sewer.

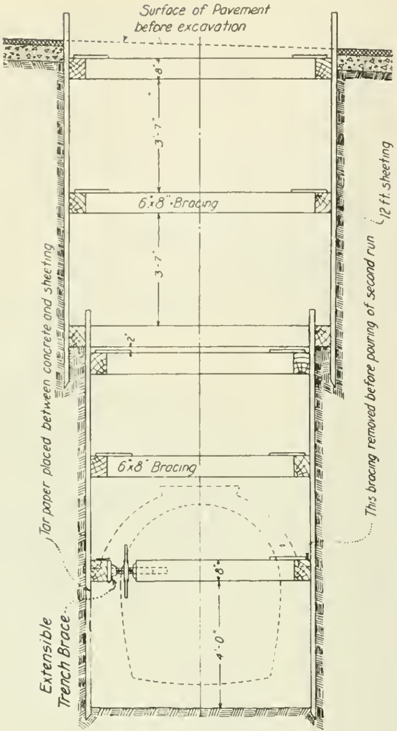
Also shows details of forms, methods of holding them in place and sequence of concreting operations.

Backfilling.—The backfilling was done by shifting the dinkey track so that the cars could be dumped into the trench. A stream of water was played upon the fill constantly and lumpy material was not allowed to remain unpuddled. The backfilling was kept close up with the concrete, and the sheeting was pulled soon after the trench was filled. A heavy timber "horse" and a block and tackle rig were used for this purpose, the power being furnished by either the gasoline locomotive or a 5-ton motor truck. Voids left by the sheeting were flushed with water. Elevations taken in sanitary sewers near the trench and parallel to it showed no settlement. However, it was necessary to remove parts of the pavement adjacent to the sheeting, because of the poor condition of both the concrete base and the wearing surface.

The street was repaved about three months after the backfilling was completed. A 10-ton road roller was used to compact the sub-grade, upon which a 6 in. base of 1:2½:6 concrete was laid. The asphalt was placed by the Andrews Asphalt Paving Co. of Hamilton.

The sewer was begun in August, 1918, and completed in April, 1919. The quantities were as follows: Earth excavation 11,453 cu. yd.; rock excavation, consisting of old foundations and concrete base, 303 cu. yd.; concrete, 1,133 cu. yd.; reinforcing steel, 79,600 lbs.

Construction Methods for Wood St. Sewer.—In the central part of the city there is an area of about 132 acres, which until recently was served by a storm sewer on Wood St. discharging into the river north of the Columbia bridge. This sewer has a manhole at each street intersection, and as the surface of Wood St., west of 2nd St., is below the maximum flood stage to be expected (elevation 586 ft.), it was necessary to place a floodgate at its outlet. A reinforced concrete circular storm sewer, 4 ft. in diameter and 1,588 ft. long, has been built on Wood St., from 2nd St. to the river, parallel to the old sewer, to drain by gravity during extremely high river stages the 106 acres of the aforementioned area lying above elevation 586 ft. The desired condition was obtained by building a tight sewer and connecting it with the old sewer at the existing manhole at 2nd St., leaving a dead end on the old sewer at which a standard manhole was built. The elevation of the flowline at the connection is 580 ft. (the street surface here being elevation 590 ft.) and the new sewer is built on a grade of 0.6 per cent, having a capacity of a little over 100 cu. ft. per second. On the river side of the levee the old sewer was connected with the new one, a gate manhole being built in the old sewer at the levee. Thus for all ordinary stages of the river the 26 acres still served by the old sewer are drained through the outlet of the new sewer. There are no manholes or other openings in the new sewer except a standard manhole at the center line of the levee, the top of which at elevation 589, is flush with the top of the levee. West of the levee the sewer is of horseshoe shape, on a grade of 9.7 per cent. As precaution against underwashing the outlet structure and


Surface of Pavement before excavation
8"
3'-7"
6"x8" Bracing
3'-7"
2"
6"x8" Bracing
8"
4'-0"
12 ft. sheeting
Tar paper placed between concrete and sheeting
This bracing removed before pouring of second run
Extensible Trench Brace

TYPICAL SECTION

Fig. 3—Method of Shoring Trench.

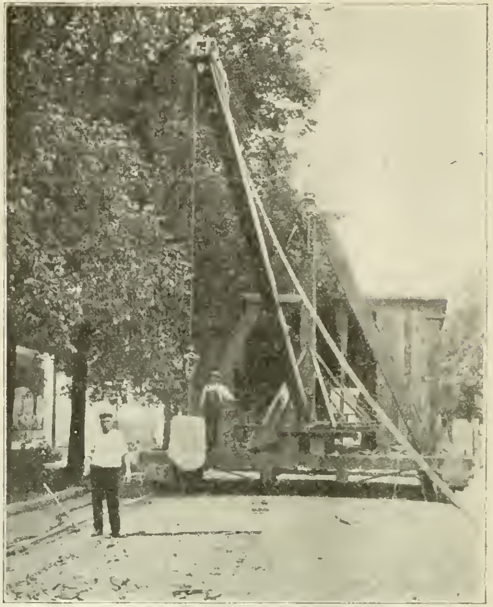


Fig. 5—Breaking Concrete Pavement Base.

The 6-in. concrete base on Wood street was broken by dropping a 1-ton hammer on it, worked by the excavating derrick, thus averting the laborious process of breaking it with a sledge. At Buckeye street the concrete base, owing to its inferior quality, was readily removed by the clamshell bucket.

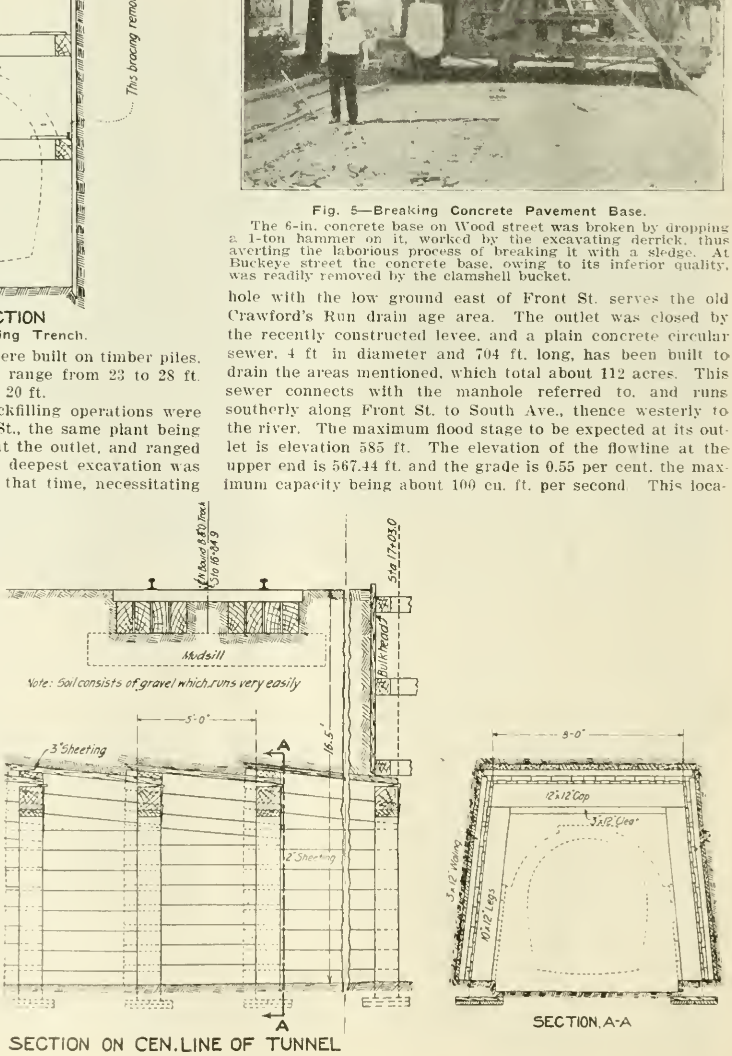
the horseshoe portion of the sewer were built on timber piles. The piles under the outlet structure range from 23 to 28 ft. in length, and the balance from 15 to 20 ft.

The excavtion, concreting and backfilling operations were practically the same as at Buckeye St., the same plant being used. The depth of cut was 18 ft. at the outlet, and ranged from 7 to 10½ ft. on Wood St. The deepest excavation was about 6 ft. below the river level at that time, necessitating pumping, a 4 in. centrifugal pump driven by a 25 h.p. electric motor being used. Wood St. is paved with asphalt on a concrete base east of Monument Av., and to facilitate its removal the concrete was broken, by dropping a 1-ton hammer on it by the derrick as shown in Fig. 5. The asphalt was cut by an improvised rolling disc, placed on a pin between the timbers, and wedged under the derrick.

The street has not as yet, been repaved. This will be done in conformity with the original specifications.

The job was begun April 9, 1919, and completed July 31, 1919, the quantities being as follows: Earth excavation, 4,600 cu. yd.; rock excavation, 186 cu. yd.; concrete, 665 cu. yd.; reinforcing steel, 21,700 lb.; timber piles, 900 lin. ft.

Front St. Sewer. There is an area lying between Wood St. and South Ave., that has been served by a storm sewer that run southerly on Front St. to a manhole at the old Crawford's Run crossing thence westerly in an open channel to the river. A sewer connecting the manhole with the low ground east of Front St. serves the old Crawford's Run drain age area. The outlet was closed by the recently constructed levee, and a plain concrete circular sewer, 4 ft in diameter and 704 ft. long, has been built to drain the areas mentioned, which total about 112 acres. This sewer connects with the manhole referred to, and runs southerly along Front St. to South Ave., thence westerly to the river. The maximum flood stage to be expected at its outlet is elevation 585 ft. The elevation of the flowline at the upper end is 567.44 ft. and the grade is 0.55 per cent. the maximum capacity being about 100 cu. ft. per second. This loca-



SECTION ON CEN. LINE OF TUNNEL

SECTION, A-A

Fig. 4—Method of Tunneling Under B. & O. R. R.

tion was selected with the idea of draining still another area, farther south, in the event of a storm sewer being built on South Ave. The cross-section of this sewer is the same as that of the Wood St. sewer. There is a gate manhole at the intersection with the levee, back of which no openings were placed.

Construction methods were the same as at the other sewers, but the trench was not completely backfilled because this portion of Front St. is within the limits of the spoil bank to be filled by the excavation from the river channel. The average cut was about 12 ft., and the material removed consisted mainly of rubbish from the city dump. This part of Front St. has never been paved. Excavation began Aug. 13, 1919, and the sewer was completed Oct. 18, 1919. The quantities consisted of 2,750 cu. yd. of earth excavation, 310 cu. yd. of concrete, 1,700 lb. of steel, and 680 lin. ft. of timber piles.

C. H. Eiffert, Division Engineer, is in charge of the local flood protection work at Hamilton, and Mr. McWhorter, as Assistant Division Engineer, has had direct charge of the sewer work. F. C. Williams served as superintendent from the beginning of the work to March 1, 1919, when he resigned and was succeeded by W. A. Roush.

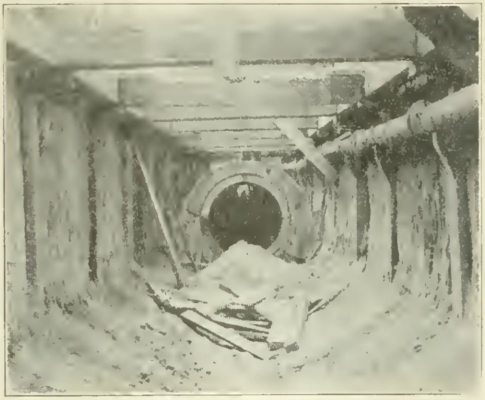


Fig. 6—Trench for Wood Street Sewer.

The fine, loamy sand on this portion of the sewer required but little shoring. The water main seen against the bank was successfully jacked over from the middle of the trench without interrupting the water service. It was necessary to recalk only a few of the joints.

Cost of C. I. Water Main Construction at Pasadena, Calif.—The accompanying table, from the recently issued annual report of the Water Department of Pasadena, Calif., shows the average unit cost of constructing cast iron water mains in that city. The basic price paid by the city for common labor per 8-hour day has been as follows:

Nov. 1, 1912, to June 30, 1917	$2.40
July 1, 1917, to June 30, 1918	2.65
July 1, 1918, to June 30, 1919	3.00

COST PER FOOT OF CAST IRON MAIN CONSTRUCTION BY FISCAL YEARS.

	Fiscal year ending June 30,	No. feet laid.	Unit costs				
			Labor.	Auto.	Material.	Overhead.	Total.
4-in. Class "B"	1914	15,713	$0.222	$0.012	$0.487	$0.059	$0.780
	1915	27,021	.241	.016	.430	.063	.750
	1916	12,453	.268	.024	.457	.097	.846
	1917	14,670	.267	.015	.477	.058	.817
	1918	11,020	.298	.022	.743	.107	1.170
	1919	4,890	.424	.061	.885	.155	1.525
6-in. Class "B"	1914	19,878	.257	.017	.678	.076	1.028
	1915	6,691	.356	.031	.668	.097	1.152
	1916	12,546	.296	.022	.610	.117	1.045
	1917	11,636	.252	015	.673	.071	1.011
	1918	9,247	.333	.029	1.120	.148	1.630
	1919	3,583	.458	.071	1.157	.188	1.874
8-in. Class "B"	1914	11,955	.323	.018	1.042	.107	1.490
	1915	1,622	.374	.031	1.063	.135	1.603
	1916	2,748	.478	.021	.829	.171	1.499
	1917	7,323	.419	.024	1.010	.110	1.563
	1918	1,774	.390	.027	1.617	.203	2.237
	1919	2,007	.474	.068	1.679	.240	2.461
10-in. Class "B"	1914	3,541	.385	.006	1.290	.123	1.804
	1915	1,831	.422	.025	1.270	.158	1.875
	1917	749	.494	.033	1.413	.147	2.087
12-in. Class "B"	1914	8,588	.410	.024	1.600	.180	2.214
	1917	1,674	.643	.056	1.953	.195	2.847
	1919	688	.813	.082	2.986	.421	4.302
14-in. Class "B"	1916	1,200	.568	.032	1.834	.291	2.725
20-in Class "B"	1915	3,053	.781	.061	2.732	.315	3.889
24-in. Class "B"	1917	2,266	1.870	.251	5.742	.594	8.457

All Unit Prices include removal and replacement of street pavement.

The New Illinois Waterway

The completion of the proposed Illinois Waterway will mark the end of some 40 years of effort on the part of engineers and others interested in providing navigation from the Great Lakes south to the Gulf of Mexico. The producers of the Illinois valley, including Chicago, should then be able to compete with the east for Central and South American trade.

Mr. M. G. Barnes, Chief Engineer of the Division of Waterways of the Illinois State Department of Public Works and Buildings, described this project and also outlined abandoned projects in a paper read before the recent 35th annual convention of the Illinois Society of Engineers at Urbana, Ill. The following extracts are from his paper:

In the Mississippi valley there is a network of approximately 15,000 miles of waterways now in operation or being developed that will soon be able to transport immense quantities of products at a rate greatly reduced below the rail rate from Chicago to New York. The cities thus accommodated have a population of 53,539,000 people and an area of 1,725,000 square miles and is the great granary and meat region of the world.

Chicago is at the head of navigation of the great inland water system, but is separated from the Mississippi valley system by a reach of only 65 miles of non-navigable waters.

The west has been doing much business through the city of New York, to such an extent that the port of New York now does approximately three-fourths of the foreign and coastwise business of the Atlantic and Gulf ports. That port has become so congested that railroads maintain a differential against it in a vain attempt to divert business to other points.

The middle west has grown to such importance that it feels keenly the disadvantages of attempting to deliver its commodities to foreign countries through the port of New York. In normal times freight rates from the Mississippi valley to that port were greater than the rates from Argentine to the port, and now the farmers of Argentine can deliver their corn to the port of New York at least 10 ct. a bushel less than it would cost to move it from the states of Iowa and Illinois. The first-class rail rate from St. Louis to Salt Lake City is $7.72; the water rate from St. Louis to Buenos Aires is $7.33; the first class rate by rail to Denver is $2.02½, and the water rate from St. Louis through the Panama canal to Manila is $1.93½, or, in other words, the rate by water, one-third the way around the world, is less than from St. Louis to Denver.

In 1917 the total manufactures of the city of Chicago amounted to at least 50,000,000 tons annually and its wholesale trade to 60,000,000 tons. The amount of bituminous coal used in the city annually exceeds 30,000,000 tons and is increasing at the rate of 1,000,000 tons a year and has been so increasing for at least the past two decades. Practically all of this coal comes from Southern Illinois points.

South and Central American countries are just now coming into their own and feel their importance in matters of commerce and trade. These are Chicago's nearest foreign neighbors and with the completion of an adequate waterway system the trade with these countries should rapidly reach great proportions.

Ever since the early 80's waterway advocates have been attempting to secure the adoption of some waterway project that would connect Chicago with the great inland Mississippi system and permit of a cheaper means of transportation.

The Chicago Sanitary District has completed a waterway southward about 37 miles to Lockport, having a depth of upward of 21 ft. and width of 160 ft.

In 1908 the people of the state of Illinois amended the state constitution permitting the expenditure of $20,000,000 for a waterway connecting the lower end of the Sanitary Canal at Lockport with the improved channel of the Illinois River, at or near Utica, a reach of approximately 65 miles. Many plans and projects have been submitted for the carrying out of the wishes of the people as expressed at the election of 1908.

Plans were first drawn by Chicago engineers calling for a canal of such dimensions as would accommodate Great Lakes and ocean-going vessels, drawing not over 24 ft. These plans contemplated several power plants, but, before the project got beyond the promotional stage, it was found that the cost would be greatly out of proportion to any benefits that might be derived from the completion of the enterprise. About that time, Congress appointed a board of engineers from the

United States Engineer Corps, together with one civilian engineer, to make a very complete study of the whole project of the waterway connecting the Great Lakes with the Gulf system and reported their findings in House Document No. 762—63rd Congress, 2nd session. The finding of this board was against a channel designed for ocean and lake shipping, and also opposed to the so-called 14-ft. project that had been proposed as the first step in carrying out of the 24 ft. project. During Gov. Dunne's administration another board of engineers, appointed by the governor, made still another study of this now complicated problem and reported advocating a waterway with locks 45 ft. in width and 250 ft. in length. After some delay the Secretary of War returned the request for a permit for this project without his approval. Such was the status of affairs when Gov. Lowden began his administration.

It was at this time that the writer was called in to make yet another investigation of conditions, to study plans of other engineers, and to advise as to the proper design of a waterway and estimate its probable cost. After giving this project careful consideration, it was found that none of the projects thus far brought forward seem to meet the situation, hence he ventured still another plan which it was believed would meet the approval of the Federal authorities and be best adapted to the rivers to be navigated. Upon study of the 24 ft. project it was found that its cost might be even greater than the cost of the Panama Canal if one takes into consideration the cost of maintenance and operation. It was also believed that, at least for the present, greater advantages would accrue from the use of a barge canal or waterway, even though it might be necessary to unload from the barges to ship from New Orleans to Chicago. The cost of transportation by barge over these waters would be less than if carried on ocean bottoms and there is the added advantage of their being loaded in relatively shallowed draft barges of small tonnage that could be delivered to individual shippers and also could float on waters other than the main channel between Chicago and New Orleans, hence permitting of greater elasticity and a more universal use of the waterways. Considering the nature of the Mississippi valley streams to be navigated, it will be seen that they are almost universally wide and shallow waterways of great length. To improve such waters to any depth greatly in excess of what nature provided would be expensive in first cost and entail enormous annual charges. The unusual width and relatively low velocities of these streams appeared to lend themselves peculiarly to the floating of shallow craft. With this in mind, a waterway was planned that should meet the natural conditions without excess in cost, and, at the same time, would permit of greatest use of the waters and at a minimum of transportation costs.

Locks were provided with horizontal dimensions of 110 ft. width and 600 ft. usable length. The miter sills were placed 14 ft. below extreme low water. Inasmuch as the Illinois River below Utica is less than 8 ft. in depth, the Mississippi River below St. Louis only 6 ft. in depth, and the Ohio is improved to a 9 ft. depth, it was believed to be unwise at this time to excavate the connecting channels between the locks to the greater depth of 8 ft. in earth and 10 ft. in rock. However, structures were so designed and located that should it ever be found advisable in future to create a 14 ft. waterway this could be done with the existing permanent structures by simply excavating greater depth in the pools connecting them.

The work has been so laid out as to permit of the greatest possible development of the water resources of the stream, both navigation and power. After this project was placed in the hands of Governor Lowden, the Legislature of 1919 passed a new waterway act calling for locks 110 ft. wide, 600 ft. usable length with 14 ft. of water over miter sills and have connecting pools 8 ft. in depth in earth, 10 ft. in rock and the channel having a bottom width of at least 150 ft. This waterway act repealed the act of 1915.

Since the bill became a law, the Department of Public Works and Buildings has organized an engineering force employed on the design of the various structures. Application has been made to the War Department for approval of plans of the waterway. The plans have met the approval of the Chief of Engineers of the U. S. A. and the Secretary of War. The people of the state of Illinois have voted $20,000,000 to defray the cost of the waterway. It appears, therefore, that this very important waterway has passed practically all of the hurdles placed in its way. With the construction completed, Illinois will have a waterway capable of transporting fleets of 7,500 tons each without frigating the bulks at the locks.

Sewerage Conditions in Illinois

Out of a total of 1,060 municipalities in Illinois, only 201, or 19 per cent, have sewerage systems of any kind. The municipalities having a population over 1,000, according to the 1910 census, number 369. Of these, 189, or 51 per cent, have sewerage systems. These figures and some interesting deductions were given in a paper read by M. C. Sjoblom, Assistant Engineer, Illinois Department of Public Health, before the 35th annual convention of the Illinois Society of Engineers.

Mr. Sjoblom states that the rule might well be adopted that a village should install a complete sewerage system as soon as possible following the installation of a public water supply, and only under very unusual conditions should a village be permitted to reach a population of 1,000 without having a sewerage system installed. By the time the population has reached 1,000, sewers may almost be considered a necessity.

A count of the towns having 1,000 population or less in 1910 shows that there were 691 in Illinois, of which 416 had a population less than 500. None of the towns in this latter class has sewers, while there are 12 towns between the 500 and 1,000 population class that have systems.

There are 369 cities in the state which have a population over 1,000, 189 of which have sewerage systems. Of the 189, there are 87 systems which are in towns that have a population over 4,000; 49 per cent of the cities and towns with a population more than 1,000 are without sewerage systems. The population figures used are from the 1910 census. Many of the towns have doubtless grown so that they do not fall within these classes, which makes conditions worse than presented. Many of the towns credited with systems would show upon examination to be only partially or very incompletely served. Further extracts from Mr. Sjoblom's paper follow:

But if we are to demand that the people pay for sewerage systems, we should make every honest effort to see that the improvement will be as permanent as possible and that it conforms to the best engineering practice. Illinois offers many instances where the sewerage systems are improperly designed. Systems are built without regard to any comprehensive plan, future requirements, or whether treatment may be required some time hence, but solely to serve one or two sections of a town for its immediate needs.

In a number of cases the fault lies largely with the various communities which have engaged inexperienced engineers. In other cases, unscrupulous engineers attempt to build a system far below the cost of an adequate system. The cost of engineering services is a small part of the improvement, yet it is this item which very frequently determines the engineer to be retained. Sanitary engineers should insist that a complete study be made in a community before attempting to install any system. For an engineer to permit his better judgment to be overcome in such a matter does not win the respect of his clients and later is quite sure to reflect on the engineer in charge and often on the engineering profession as a whole.

Where treatment plants are installed, whether these provide for sedimentation alone or include secondary treatment, the engineer should give special attention to emphasizing the necessity of systematic supervision during operation. At present, the average Illinois treatment plant is shamefully neglected and a large part of the blame rests on the engineer who pays no attention to it after it has once been built.

At best, a treatment plant is not an asset to a community, but with careful design, adequate supervision during operation, the engineer will gain more confidence of the community and the citizens in general.

Texas Waterworks Association Formed.—Waterworks and filtration plant operators attending a special short course of instruction at the University of Texas have effected a permanent organization to be known as the "Texas Waterworks Association." E. L. Fulkerson, superintendent of the Waco water plant and secretary of the Southwestern Water Association, was elected president.

A Page from Recent Waterworks Reports

Cost of Meter Repairs at Los Angeles, Cal.—During the year July 1, 1918,-June 30, 1919, the meter and service department of the Bureau of Waterworks and Supply of Los Angeles, Calif., repaired 8.234 water meters at an average cost of $1.45 per meter. The average costs of this work for the various sizes of meters are given as follows in the last annual report of the Board of Public Service Commissioners:

No. of meters.	Sizes, in.	Average cost per meter.
6,444	⅝	$1.15
522	¾	1.68
203	1	1.99
217	1½	2.41
242	2	2.97
118	3	2.88
451	4	3.00
37	6	7.63
8,234	All	1.45
Meters tested.		
12,275	...	.114
Miscellaneous work on 100,000 meters in service.	..	.0155

Cost of Operating Ford Automobiles by Water Department.—The water department of Pasadena, Calif., had 9 Ford automobiles in service during the fiscal year ended June 30, 1919. The total mileage covered by these cars was 78,981, or an average of 8,775 per car. The total hours in service averaged 2,192 per car. The average cost per car, according to the last annual report of the department, was as follows:

	Average cost per mile.
Tires, tubes	$0.0113
Gas and oil	.0124
Other material	.0036
Labor	.0065
Overhead	.0071
Total operation	$0.0409
Depreciation	.0107
Total cost per mile	$0.0516
Average mileage	8,775
Miles per gal. gas	16.55
Miles per gal. oil	589
Average hours in service	2,192
*Cost per hour	$0.2598

*Includes depreciation.

Expense Ratios and Cost of Water Sold at Pasadena, Calif.—The waterworks system of Pasadena, Calif., is a consolidation of three private systems purchased by the city on Nov. 1, 1912, by means of a bond issue of $1,250,000. Since then four smaller water systems have been purchased from the revenues of the department. The total investment to June 30 last was $1,726,649, and the value at that date was $1,453,702. The sources of supply is by gravity from a mountain stream and by pumping. Of the total water production of 288,618,620 cu. ft. in the fiscal year ending June 30, 1919, 123,017,750 cu. ft. was pumped, and 165,600,875 cu. ft. was gravity supply. The following table from the last annual report of the water department shows the ratio of expense to cost of water sold.

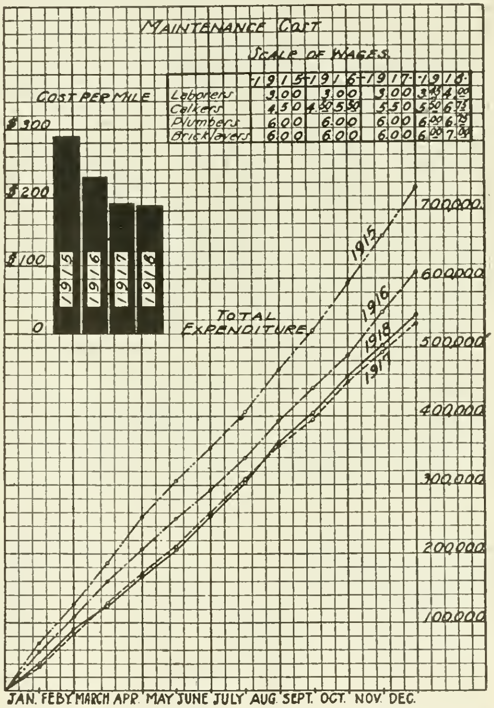
	Amount.	Percentage of total expense.	Percentage of water revenue.	*Cost of water per 100 cu. ft. (cents).
Water collecting system	$ 5,709	3.08	2.28	.23
Pumping system	26,749	14.41	10.65	1.09
Tot. cost water production	$ 32,458	17.49	12.93	1.32
Distribution	14,634	7.89	5.83	.60
Commercial	16,987	9.16	6.78	.69
General	14,791	7.97	5.89	.60
Grand total operation and maintenance	$ 78,870	42.51	31.43	3.21
Depreciation	59,168	31.90	23.59	2.41
Interest	47,468	25.59	18.92	1.93
Total	$185,507	100.00	73.94	7.55

*Based on water sales of 245,815,300 cu. ft.

Comparative figures for the previous four years are given in the report as follows:

	Percentage of total expense.	Percentage of water revenue.	Cost of water per 100 cu. ft. (cents).
Year ending June 30, 1918—			
Operation and maintenance	40.2	27.4	2.73
Depreciation	32.5	22.2	2.21
Interest	27.3	18.7	1.86
Total	100.0	68.3	6.80
Year ending June 30, 1917—			
Operation and maintenance	34.9	25.3	2.72
Depreciation	34.5	25.0	2.69
Interest	30.6	22.1	2.37
Total	100.0	72.4	7.78
Year ending June 30, 1916—			
Operation and maintenance	35.6	22.6	2.65
Depreciation	34.1	21.6	2.54
Interest	30.3	19.2	2.25
Total	100.0	63.4	7.44
Year ending June 30, 1915—			
Operation and maintenance	35.6	24.1	2.91
Depreciation	29.4	19.9	3.41
Interest	35.0	23.7	2.87
Total	100.0	67.7	8.19

Maintenance Cost of Water Distribution System of Chicago.—The cost of maintaining the 2,871.57 miles of mains in the water distribution system of Chicago amounted to $548,108 in 1918, an average of $192.15 per mile. In 1917 the average cost was $193.60. The accompanying diagram reproduced from the 1918 report of the Department of Public Works gives an interesting comparison of the maintenance costs for the years 1915 to 1918.



Cost of Motor Truck Operation by a Water Department.—During the fiscal year ending June 30 last the water department of Pasadena, Calif., had four motor trucks in service. The operating costs are given as follows in the last annual report of the department:

	1-ton truck. Per mile.	Ton truck. Per mile.	1-ton truck. Per mile.	2-ton truck. Per mile.
Tires, tubes	$0.0014	$0.0189	$0.0068	$0.0076
Gas. oil	.0228	.0309	.0255	.0377
Other materials	.0043	.0258	.0019	.0049
Labor	.0053	.0166	.0070	.0100
Overhead	.0072	.0195	.0087	.0127
Total operation	$0.0410	$0.11119	$0.0499	$0.0729
Depreciation	.0354	.0776	.0438	.0913
Total cost per mile	$0.0763	$0.1895	$0.0937	$0.1642
Mileage	4,644	2.747	4,248	5,996
Miles per gal. gas	8.73	6.73	7.81	4.66
Miles per gal. oil	379	143	340	111
Hours in service	2.152	1.036	2,043	2,084
*Cost per hour	$0.1647	$0.5022	$0.1949	$0.4723

*Includes depreciation.

Economic Oil Pipe Lines

An interesting discussion of the advantages of the oil engine as a means of transporting oil for long distances through pipe lines and a comparison of the cost of pipe line transportation with that of rail and canal transportation were given by Mr. S. A. Sulentic in a paper presented Dec. 3 at the annual meeting of the American Society of Mechanical Engineers. The paper, an abstract of which follows, also gives simple formulas that will make it comparatively easy for any one to make quick calculations of the pressure, net horsepower and brake-horsepower necessary for the transmission of any quantity of oil per day through a pipe of known diameter.

The cheapest method of overland transportation of oil is by pipe line. The cost in comparison to rail transportation is low, and yet when the rail cost is based on everyday practices, the amount seems very small. For instance, the management of an eastern railway, wishing to impress upon its clerical employees the importance of economy, posted the following notice: "For every lead pencil you waste we have to haul one ton of freight one mile."

The cost of a pencil has always been regarded as being insignificant, but when it is considered that it is equivalent to the cost of the above-mentioned haul, a similar comparison with pipe-line transportation should be interesting. The carrying of one ton of freight for one mile at the cost of a lead pencil is very cheap transportation. One or two cents per ton-mile is a low rate. Canal transportation, after allowing for the proper fixed and maintenance charges, may be lower than the rail charges by 60 per cent or even more.

In order to make a very crude estimate of the cost of transporting oil by pipe line when using equipment of the highest economy, assume a single line operating under the following conditions at a load factor of 80 per cent for 300 days per year:

Size of line, in.	8
Length of line, miles	33
Pressure of line, lb. per sq. in.	700
Rate of discharge, bbl. per hour	900

At this rate the discharge would be 21,600 bbl. per day, or 6,480,000 bbl. per year of 300 days. Assuming 6.5 bbl. per ton, the yearly discharge would approximate 1,000,000 tons. The work equipment of this discharge would be 33,000,000 ton-miles, calling for the continuous expenditure of 257 hp. Assuming the mechanical efficiency of the engine to be 75 per cent, the actual horsepower necessary to install would be 257 ÷ 0.75, or 342.

The assumed costs would be as follows:

Line: 33 miles at $1.65 per foot	$287,500
Right of way at $0.25 per rod	2,640
Freight: 79 cars at $250	19,750
Haulage: 900 tons at $14.50	13,050
Laying pipe at $0.075 per foot	13,060
Burying pipe at $0.20 per foot	34,850
Engines, pumps, installed accessories	68,500
Pump stations, buildings and foundations	30,000
Tanks: Two 55,000-bbl. at $18,500 each	37,000
Tanks: Two 500-bbl. at $500 each	1,000
Telegraph line: 33 miles at $550	18,150
Superintendence	2,500
Incidentals	6,000
Total assumed costs	$534,000

The operating expense, including fixed charges based on the total assumed costs, would be as follows:

Interest at 6 per cent	$32,040
Depreciation at 5 per cent	26,700
Administration	10,000
Attendance at pump stations and lines	11,500
Repairs to equipment, lines, etc.	4,000
Fuel for pumping—3,000 bbl. at $2.65	7,950
Total operating expense	$92,190

Hence the cost of operation per ton-mile under the assumed conditions would be $92,190 ÷ 33,000,000 = $0.0028, or 2.8 mills per ton-mile. As the relation between the cost of pipe-line transportation and rail transportation is in the ratio of 1 to 10, it is easily seen that the waste of a lead pencil in a pipe-line enterprise would be the equivalent of the cost of transporting 10 tons of oil one mile.

It should be noted, however, that almost all of the pipe-line costs are fixed and are mainly independent of the amount of oil pumped. As a result, the transportation cost per ton-mile will vary almost inversely with the load factor of the line. If this hypothetical pipe line should be operated only one-tenth of the time assumed, the unit transportation cost would equal the rail cost. Furthermore, these figures are based on a life of 20 years (5 per cent amortization). A railroad would probably be used for various classes of freight as long as it existed, but a pipe line is of service only as long as oil is presented for transportation. If the pipe line in question were to become obsolete in 10 years through the exhaustion of the oil fields or other causes, the ton-mile cost would be greatly increased.

These figures have not been presented as those of an average case, but only offered as "food for thought." In further consideration of the subject, however, it will not be out of place to give a few figures and examples showing the relations existing between pressure, capacity, diameter, length of line and power required.

Disregarding viscosity, the general hydraulic formula for friction head in a pipe discharging a uniform volume is

$$F = k\,\frac{v^2L}{2gD} \qquad (1)$$

in which

F = friction head in feet of water = lb. per. sq. in. ÷ 0.433.
k = friction coefficient for 38 gravity oil = 0.024.
v = velocity of flow, ft. per sec.
g = acceleration of gravity = 32.2 ft. per sec. per sec.
L = length of line, ft.
D = diameter of line, ft.

The formula for pressure in the line may be stated as

$$P = 0.433k\,\frac{v^2L}{2gD} \qquad (2)$$

in which P = pressure in line in pounds per square inch.

The discharge Q of the line, cubic feet per second, can be easily derived and stated as

$$Q = \frac{\pi D^2 v}{4} \qquad (3)$$

in which Q varies directly as v. Since P varies directly as v^2 in Formula (2) and Q varies directly as v in Formula 3, it follows that P varies directly as Q^2.

The net horsepower required for a pipe line may be most readily calculated if we note that the pressure per square foot is equal to the number of foot-pounds required to displace 1 cu. ft. of oil, or

$$\text{Hp.} = \frac{144PQ}{550} \qquad (4)$$

For 1,000 bbl. per day, against a pressure of 1,000 lb. per square inch, the net horsepower necessary by Formula 4 would be

$$\text{Hp.} = \frac{144 \times 1{,}000}{550}\;\frac{1{,}000 \times 5.61}{24 \times 60 \times 60} = 17$$

where 5.61 = cu. ft. per bbl.

Assuming a pump efficiency of 85 per cent, the horsepower of the engine would be 17 ÷ 0.85, or 20. Here we have a very simple rule for calculating the horsepower from barrel per day and pressure in pounds per square inch, namely,

Net hp. = 17 × thousands of bbl. per day × P ÷ 1,000
B.hp. = 20 × thousands of bbl. per day × P ÷ 1,000

For example, for a discharge of 8,000 bbl. per day against a pressure of 600 lb. per square inch, the brake-horsepower required would be 20 × 8 × 0.6, or 96. Since the horsepower varies directly as PQ and P varies directly as Q^2, it follows that hp. varies directly as Q^3. To sum up:

Velocity varies directly as the line discharge.
Pressure varies directly as the square of the line discharge.
Horsepower varies directly as the cube of the line discharge.

Another relation of value in making rapid pipe-line calculations is the ratio between the diameter D and length L, with the discharge Q and the pressure P remaining constant.

From the friction formula (2) it will be seen that P varies directly as $v^2L \div D$. Assuming P constant, L varies directly as $D \div v^2$. For the same discharge, Formula (3), that is, with Q constant, v varies directly as $1 \div D^2$. Therefore v^2 would vary directly as $1 \div D^4$. Substituting this value for v^2 above, it is seen that L varies directly as $D \div (1 \div D^4)$, or in other words, L varies directly as D^5.

This means that for the same discharge and pressure, i.e., the same friction, the length of the line would vary directly as the fifth power of the diameter. Taking a diameter of 6 in. as unity, the fifth powers of several different diameters are as follows:

D =	6	8	10	12
D^5 =	1.0	4.2	12.8	32

An example will show how easily these relations are utilized. Let a proposed pipe line be made up as follows:

Two 6-in. lines, 8 miles long (Y-branch).
One 6-in. line, 6 miles long.
One 8-in. line, 10 miles long.
One 12-inch line, 12 miles long.

With the particular oil to be transported the pressure per mile when pumping 10,000 bbl. a day through a 6-in. line will be assumed as 20 lb. per mile. What, now, will be the pressure for 17,000 bbl. per day through above line and what will be the net horsepower and brake-horsepower required?

Since P varies as Q^2, the pressure for 17,000 bbl. will be $(17,000 \div 10,000)^2$, or 2.89 times the pressure for 10,000 bbl. The pressure in the line would then be 2.89 × 20, or 57.8 lb. per mile.

Inasmuch as the velocity is halved when using two 6-in. lines for the 8-mile section, each line carrying an equal amount of oil, the equivalent length of 6-in. line for each branch would be only two miles, the length varying directly as the square of the velocity. The length of 6-in. line equivalent to the 8-in. pipe would be 10 miles divided by the ratio of the fifth powers of the diameters 6 in. and 8 in., or $10 \div 4.2 = 2.38$ miles. In a like manner the length of 6-in. line equivalent to the 12 miles of 12-in. pipe would be $12 \div 32$, or 0.37 mile. In other words, the equivalent length of 6-in. pipe in the line under consideration would total 12.75 miles. Under a pressure on the line of 57.8 lb. per mile, the total pressure on the line would be 12.75 × 52.8, or 737 lb.

Making use of the simple formula for horsepower already derived we have

$$\text{Net hp.} = 17 \times \frac{17,000}{1,000} \times \frac{737}{1,000} = 213$$

$$\text{B.hp.} = 20 \times \frac{17,000}{1,000} \times \frac{737}{1,000} = 250$$

No doubt many other useful relations could be derived for the purpose of expediting pipe-line calculations, but those which have been presented are among the most useful.

In illustration of the foregoing the following data in regard to the 36-mile, 8-in. Alton pipe line operating between Carlton and Wood River, Mo., should prove of interest. This line, constructed in 1913, has four stations, in each of which are installed four units, each consisting of a 100-hp. type F. H. De La Vergne oil engine direct-connected to a 6-in. by 18-in. National Transit Co. herringbone-geared power pump with 8-in. suction and 6-in. discharge. The performance of one station equipment (three units) is given below:

Oil pumped during 10 days, bbl.	140,000
Oil pumped per day, average, bbl.	14,000
Pressure maintained in line, lb. per sq. in.	700
Brake horsepower, average	196
Pump efficiency, estimated, per cent	85
Fuel consumed by engines during 10 days, bbl.	65.8
Fuel consumed by engines per day, lb.	2,020
Brake-horsepower-hours per day = 196 × 24	4,704
Fuel consumption per b.hp.-hr., lb.	0.43
Ft.-lb. of work per day developed by the engines = 196 × 33,000 × 24 × 60	9,320,000,000
Ft.-lb. of work per day in oil pumped = 9,320,000,000 × 0.85 (85 per cent efficiency)	7,900,000,000
B.t.u. in fuel consumed per day = 2,020 × 18,000	36,000,000
Ft.-lb. of work per 1,000,000 b.t.u.	217,000,000
Daily operating cost:	
Fuel oil: 6.58 bbl. at $1.50	$9.87
Lubricating oil: 2 gal. at $0.22	0.44
Cylinder oil: 1.6 gal. at $0.21	0.34
Attendants: Total salaries of 2 engineers, 2 assistant engineers, 1 chief engineer and 2 telegraph operators	41.50
	$52.15
Cost per b.hp.-hr. (52.15 ÷ 4,704)	0.011
Cost per bbl. of oil pumped ($52.15 ÷ 14,000)	0.0037
Bbl. of oil pumped per bbl. of fuel consumed (14,000 ÷ 6.58)	2,130

In conclusion it may be said that the comparatively small amount of power involved in pipe-line transportation lends itself admirably to the efficient use of the oil engine as a prime mover. And unless some other form of power can show better results in the immediate future, the oil engine bids fair to hold its present superiority as a means for the transportation of oil.

Muskogee, Okla., Adopts City Manager Plan.—Citizens of Muskogee, Okla., at a special election Feb. 25, adopted an amendment to the charter providing for the managerial form of government, the manager to be chosen by 16 aldermen who are to be elected and who will serve without pay. The amendment received a majority of 360.

An Improved Weir for Gaging in Open Channels*

By CLEMENS HERSCHEL
Hydraulic Engineer, New York City.

The American Society of Mechanical Engineers, having appointed a committee to draft a revised form of Power Test Code in 1917, and invited the three other Founder Societies to appoint advisory committees to the same end, the writer was appointed as one such advisory member. It thereupon very soon appeared that the matter of weir measurements and of their accuracy was in a most deplorable state of confusion. On the proper representations having been made to Engineering Foundation that a new set of experiments on weir discharge were liable to lead to a considerable advance in knowledge in this branch of applied science, it made an appropriation for that purpose, to be expended by the writer. The experiments about to be described have been the result of these preliminaries.

Apparatus Used in Experiments.—The place selected for conducting the experiments was the hydraulic laboratory of the Massachusetts Institute of Technology. Briefly stated, the apparatus used in the present experiments and shown diagrammatically in Fig. 1 consisted of a 350-H.P. Ball angle-compound engine, 240 R.P.M., direct-connected to a 30-in. Worthington centrifugal pump, having some 48 cu. ft. per second maximum capacity at 40 to 45 ft. lift. This pump takes its suction from a system of canals under the floor of the basement, which are or may be connected with the Charles River Basin.

Right here arose one great obstacle in the making of these hydraulic experiments. The canals at times took to "surging," causing oscillations of the pump-well surface, and these, in turn, were transmitted through the pump and could plainly be seen at the upstream end of the discharge pipe. They were also indicated by the 30-in. venturi meter set in line of the discharge pipe, next downstream from the pump. Two whole afternoons' work were rendered useless from this cause. But by experience and careful work any gross effect from this cause could be avoided.

The discharge pipe delivered into a riveted trough of steel, 5 ft. by 5 ft. and about 135 ft. long, at some 40 ft. higher elevation than the pump. In it was set the 16-in. by 5¼ in. venturi meter used to measure quantities smaller than about 8 cu. ft. per second (Sept. 25, 26 and 29), the larger quantities being measured by the 30-in. meter.

Both these meters were read by means of mercury straight-tube manometers, as made by the builders of the meters. The scale of these manometers was based on a coefficient of discharge for the meters of 0.99. These were the facilities at hand, or readily procurable and installable; and though not so precise as a tank measurement would have been, were sufficiently so for the pioneer work to be done. It is not often, as yet, that one can get a reservoir to hold 46 cu. ft. per second for the period of a hydraulic experiment; and in the opinion of the writer the venturi meter is the next best thing. It certainly was at the hydraulic laboratory that had been selected for making the present experiments.

That the venturi meter is of a high order of accuracy has been shown by a compilation by the writer for the Power Test Code committee of all attainable relevant experiments made with it during its existence of 30-odd years. A very significent series of tests, made by F. H. Shaw, Mem.Am.Soc. C.E., of a meter at Lancaster, Pa., show an average variation of 0.036 of 1 per cent for 44 tests covering a period of 8 years.

To return to our present meter observations: The scale of the manometers read tenths of cubic feet per second; and hundredths could readily be estimated on both the meters used.

From the 5-ft. trough the water fell into a vertical flume or wheel pit 12 ft. in diameter, made of riveted steel and 22.5 ft. high; and through a wooden adjustable flap valve in the floor of this flume, fell into a concrete tail-race pit, which, through racks and gridiron-valve gates, discharged into the concrete channel about 72 ft. long that led to the weir to be tested. The discharge of the weir fell back into the system of canals which fed the centrifugal pump, thus completing the cycle actuated by the Ball engine and pump.

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*From the February Journal of the American Society of Mechanical Engineers. Abstract of a paper to be presented at the spring meeting, St. Louis, Mo., May 24 to 27, of the American Society of Mechanical Engineers.

The free discharge of the 5-ft. trough into the 12-ft. vertical flume could be rendered somewhat less turbulent by keeping the flume-water elevation as high as possible without waste, this again being crudely controllable by means of the wooden flap valve in the floor of the vertical flume. But this whole arrangement and the free discharge through the flap valve into the tail-race pit below were imperfect arrangements, acknowledgedly only temporary in character, and were the cause, together with the "surging" of the pump-well water above referred to, of many of the difficulties experienced in making these experiments. They also were the principal cause of most of the lack of precision that remains and is inherent in the final results.

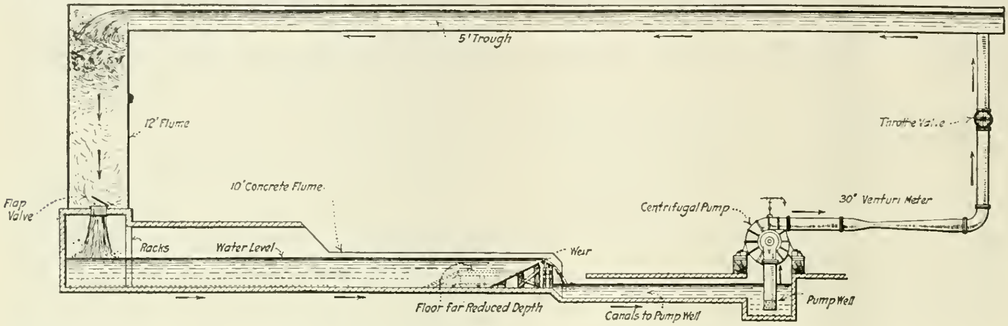


Fig. 1—Arrangement of Apparatus Used in the Experiments.

It would have been gratifying to remove some or all of these crudities, and also to greatly extend the scope of the experiments, but the limits of the appropriation available forbade going beyond the work that was actually done.

To vary the discharge, the pump operating at a uniform speed as governed by a flywheel governor, and the boiler pressure also being fairly constant, a throttle valve in line of the pump discharge pipe was used. When the small 18-in. meter set in the 5-ft. trough was in action, the quantity and constancy of the flow leading to the meter and the efficient action of the pump, in spite of the small quantities lifted, could be regulated by opening a waste valve out of the pump discharge pipe. To a minute extent, certainly sufficiently to remove all air from the pump discharge pipe before it reached the 30-in. meter, the same office was performed by keeping in action a 2-in. steam siphon, set at the extreme upstream end of the pump discharge pipe and ordinarily used to exhaust air from the pump before starting it.

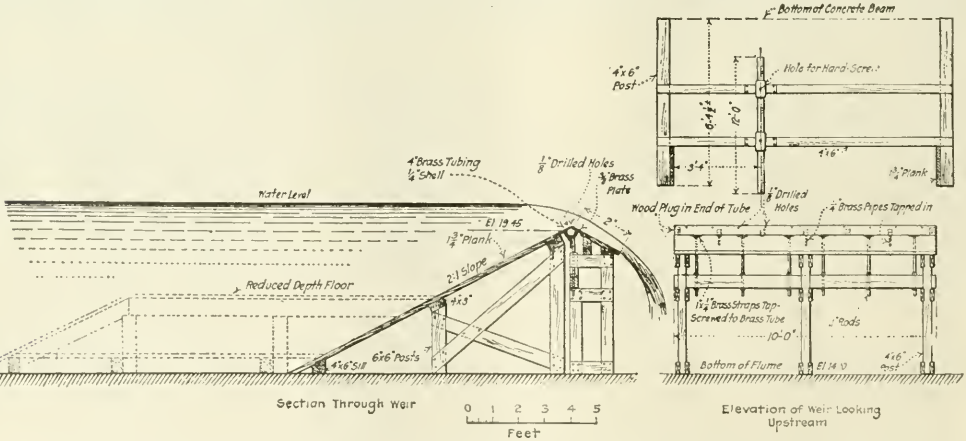


Fig. 2—Detail of New Weir (The Surface Curve of Water Discharging Over the Weir is Drawn from Measurement).

The concrete channel was nominally and almost exactly 10 ft. wide, and had at its downstream end a sharp-crested weir whose crest was about 5.35 ft. above the bottom of the channel. The new form of weir was so designed that it could be built over and around the old weir, and again removed without injury or displacement of what was found on the premises, and with its crest at nearly the same elevation above the bottom of the concrete flume.

The New Weir.—The fundamental idea followed in the design of the new weir was to have the water to be measured conducted over the weir in a gentle manner, and so to have it flow smoothly and regularly from the time it first encounters the weir construction until it leaves it. Instead of allowing the body of water to impinge with more or less violence, according to the velocity with which it approaches the weir, against a perpendicular wall in its path (the upstream face of the ordinary weir) it is gently led to the crest by a 2:1 slope. Instead of striking or being torn over a sharp edge at the crest, the crest is made in the form of the arc of a circle; and instead of bothering about air under the nappe, the nappe is supported on another 2:1 slope downstream from the crest. Moreover, the crest is made hollow, so that observations of the pressure, or lack of full pressure, whichever the water may elect to exercise, can be taken at the crest, not at a distance upstream from the crest varying according to the fancy of the experimenter.

If the quantity passing the weir turns out to be a function of this observed pressure, well and good. If not, we will see what virtue there is in the difference of water elevations or pressures, the one taken upstream from the weir and the other taken by means of the hollow weir crest.

The difference referred to proved to be the sought-for solution of the problem at hand, and hereafter it alone will be closely considered. A United States patent has been applied for, covering the weir construction herein described.

The orifice in the side of the concrete flume conducting water to the hookage pail for measuring water elevations upstream from the weir was made flush with the flume side, at a point 13.9 ft. upstream from the weir crest center, and 1.68 ft. below it in elevation.

Furthermore, to connect the water passing over the weir with the hollow of the weir crest, a series of ⅛-in. holes were carefully bored through into the latter. This was done by first tapping in a solid brass plug, and then boring in a hole ⅛ in. in diameter through this plug. A natural inclination would be to bore these holes at right angles to the surface curve of the water, but as this varies with the quantity passing the weir, such an inclination is impracticable. There are only two other natural directions for such piezometer holes—either vertical, or at right angles to the upstream slope of the weir; and if the latter, naturally at the line of tangency of that upstream slope and the arc of the weir crest. The vertical holes are called "Orifices No. 1" and those perpendicular to the 2:1 slope, "Orifices No. 2." The original intention of the writer had been to make the crest tube so that it could be revolved around its horizontal axis, and thus find the best position of the piezometer orifices, but a cumbersome and unduly expensive experiment like this was at once abandoned, and in view of the success already attained, may now be disregarded by engineers.

Both kinds of piezometric orifices were tried, and the last-named proved much the superior for general use.

To vary the velocity of approach a false bottom was put into the channel for some of the experiments. These will be designated as having been made with "reduced depth" and others with "full depth."

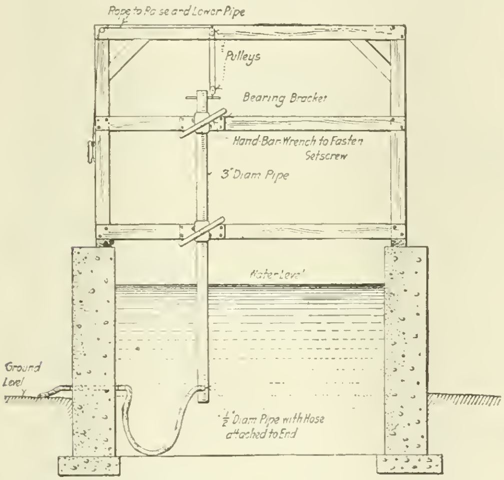

Rope to Raise and Lower Pipe
Pulleys
Bearing Bracket
Hand-Bar-Wrench to Fasten Setscrew
3" Diam Pipe
Water Level
Ground Level
½" Diam Pipe with Hose attached to End

Fig. 3—Apparatus to Observe Water Elevation Upstream for the Weir, Automatically Corrected for Velocity of Approach.

The diagrammatic drawing, Fig. 1, will make clear the description of the weir test apparatus given in the foregoing paragraphs.

To increase the quantity per foot in length of weir, the available capacity of the pump was in many of the experiments made to pass over only about 3.3 ft. of the length of weir, while other series of the experiments used a weir about 10 ft. long.

As these experiments had a practically useful end and aim—the establishing of a commendable method of weir measurements—end contractions were ruled out from the very beginning. They are of no use, ordinarily, and only complicate the situation. Even in the few cases of working with sharp-crested weirs, when side contractions are introduced so as to cause greater depths upon the weir with a diminishing quantity of water, or so as to cause a selected formula to apply, they could be avoided at the cost of a very little extra carpenter work. But with the straight-line formula about to be established and valid from zero up to the maximum found by the experiments herein described, there is no occasion whatever to change the length of the weir so as to accommodate the quantity of water about to pass it, and side contractions become either foolish or pseudo-scientific. None of the following experiments include them.

Automatic Correction for Velocity of Approach.—A vertical brass pipe dipping into the water, shown in detail in Figs. 3 and 4, was intended as a means of observing the water elevation upstream from any part of the weir, automatically corrected for velocity of approach, by taking in the water pressure through a pitot orifice pointing upstream and transmitting it to a hookage pail in the usual manner from out of the downstream side of the vertical tube. A pointer above water, parallel to the pitot tubular orifice, which should point upstream, insures its correct position. Our experience leads us to advise that the vertical tube be not used as a reservoir, but only as a support for the pitot orifice.

The tube is held in its guides by two clamp screws, and may readily be set so as to bring the pitot orifice in the locus of mean velocity as it may be judged or found. In these experiments it was set at 6/10 depth of water, and ⅓ the width of the channel from either side. A scale of feet and tenths on the tube, reading up from zero at the pitot orifice, and aided by another scale or gage painted on the side of the concrete flume, reading up from zero at the flume bottom, readily permitted this. The apparatus is mounted on two beams crossing the water channel and at a convenient height above it.

This apparatus exists as yet only in theory and should be experimented with at the first favorable opportunity, because on drawing the water out of the flume at the close of our experiments a broken and leaky joint was discovered in the rubber pipe that carried the water pressure from the vertical tube to the hookage pail, so that the readings taken proved unreliable, or of no record value whatever.

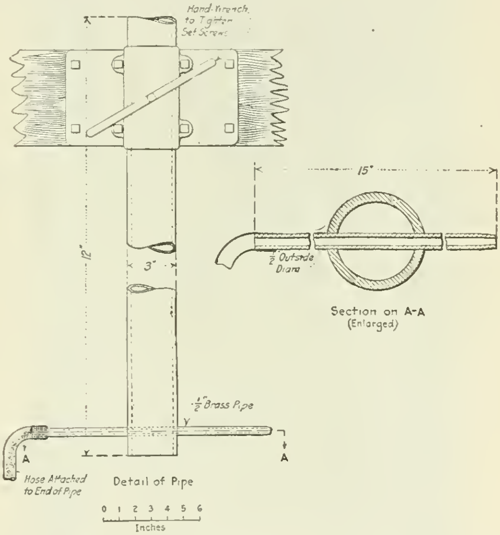

Hand-Wrench to Tighten Set Screws
12"
3"
15"
½" Outside Diam
Section on A-A (Enlarged)
½" Brass Pipe
A
A
Hose Attached to End of Pipe
Detail of Pipe
0 1 2 3 4 5 6
Inches

Fig. 4—Details of Apparatus Shown in Fig. 3.

Need and Scope of Further Experiments.—A crew of six men, including three observers, with a captain, had been working with the apparatus from Sept. 10 to Oct. 3, 1919, and it was with great regret that the writer gave the order to dismantle the weir because so much remained to be discovered. But Oct. 3 was Friday, the last day of the week for us. The laboratory closed at 5 p. m., and on Monday the regular school term commenced. The appropriation for the work was nigh exhausted and it was high time we quitted the premises.

There was, first of all requiring further investigation, the effect of the radius of the weir crest. Bazin had experimented on a weir composed of two 2:1 slopes meeting at a sharp angle and with a little pipe to indicate pressure "under the nappe," let into the body of the weir slope upstream from the crest. This can not enlighten us very much, but is the nearest approach to our experiments known to the writer.

Our weir crest had a radius of 0.198 ft., and the outside surface was hard and smooth oil paint

No doubt the radius of the weir crest is a factor in the application of the formula found for weirs of the construction shown in this article, but it remains for other sets of experiments to reveal the limits and detailed effects of this radius.

The Experiments.—The record of the 40 experiments made is given in Table I. Four of them have been marked doubtful on account of actual or supposedly defective observations and all those made Sept. 9 and 30, also part of those on Sept. 25, had to be rejected as worthless on account of the previously mentioned violent "surging" of the water discharged by the pump.

A separate set of gagings was made Oct. 3 to compare the indications of the Institute's sharp-edged weir with the Institute's 30-in. venturi meter. Owing to the fact that his meter is set in line of the pump discharge pipe, only 12 ft. distant from the pump, it had been a question whether at that short range it would meter accurately, and the experiments of Oct. 3 were made for the purpose of answering this question. The system for observing head on the weir, available, was that known as the Fteley and Stearns method. A metal plate was set in the side of the concrete flume, flush with it, and an orifice in this plate in the present instance was situated 6.8 ft. upstream from the crest and 1.68 ft. below it in elevation, connected with a hook-gage pail in the usual manner.

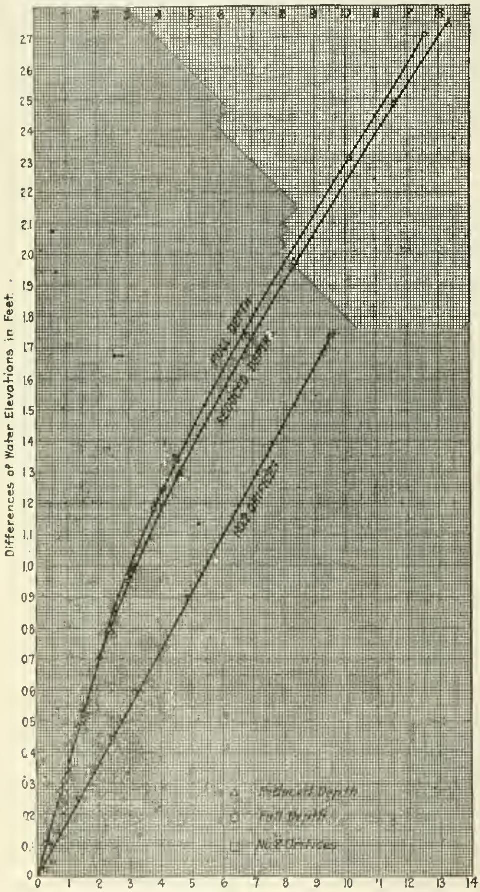


Fig. 5—Diagram Showing Results of the 40 Experiments.

RECORD.

Pump started about 12:30 p. m., discharging 30 cu. ft. per sec. at 1 p. m. All quantities corrected for velocity of approach.

	Weir.	Meter.
Oct. 1, 1919—	Cu. ft. per sec.	
2:05 to 2:10 p. m., both inclusive	38.13	38.30
2.50 to 2:55 p. m., both inclusive	30.33	31.25
3:50 to 3:55 p. m., both inclusive	17.91	18:80
4:40 to 4:45 p. m., both inclusive	11.73	11.00

Having in mind the imperfections of the whole test apparatus from the canals in the basement, through the pump, riser, 5-ft. trough, 12-ft. vertical flume, wooden flap valve, into the 10-ft. concrete flume, and over the weir, as already mentioned, it is quite possible that 38.13, 30.33, 17.91 and 11.73 cu. ft per second were passing the weir on the average for 5 minutes, while 38.30, 31.25, 18.80 and 11.00 cu. ft. per second were being discharged by the pump on the average during the same 5 minutes. The difference could very well represent rise or fall in the mean elevations of the water in either the 5-ft. trough, the 12-ft. vertical flume, or in the 10-ft. concrete flume, or in two or more of these containers simultaneously.

The comparison which was made, alone, does not argue for superior exactness of gaging by either the weir or the meter—that must be determined by tank tests made with the two separately. It only showed that neither was materially inexact. And we know from data that have been given that next to tank tests the venturi meter is an exact method for measuring water.

And with the result placed in evidence, that No. 2 orifices act according to the straight-line equation—

$$Q = 5.50d \text{ in English units}$$

$$Q = 1.675d \text{ in metric units}$$

this paper might fitly close.

Fig. 5 shows the results of Table 1 in graphic form.

One word more, however, the writer allows himself in relation to the formula for weir discharge. It had been his intention not to evolve any formula, but to present the result of his experiments in the form of a table, arranged somewhat as are tables of logarithms, so that quantities could always be ready at a glance from the data observed. No one cares for the formulæ by means of which logarithms are computed; their use would not be furthered by a study of them. No more need a Power Test Code contain formulæ for weir discharge; a table would answer its purposes more fittingly.

But the exceeding simplicity of the weir formula appurtenant to the form of weir herein presented upset this plan. Such a weir does not need so much as a table to look up or to compute its discharge. All one has to do is to measure the length of the weir and then multiply it by 5.5 and by the difference in head.

But there remains the question, why 5.5? Why not 20, or any other quantity? And for the mitigation of the stated laudable curiosity, further experiments will no doubt be undertaken in the course of time; and much ink of disquisition may yet be set adrift.

Railroad Conference of A. A. E.—The second Railroad Conference of the American Association of Engineers will be held March 15 in the Florentine Room of the Congress Hotel, Chicago, Ill. Subjects of vital interest to all professional engineers in railroad service will be presented.

TABLE 1—EXPERIMENTS WITH THE HERSCHEL WEIR.

Date, 1919.	Length of run. P. M.	Velocity of approach, ft. per sec.	Depression = Piezometer height (corrected for velocity of approach) less weir indication. As measured.	Corrected for v. of a.	Quantity per ft. of weir length, cu. ft. per sec.
Sept. 10[1]..	2:45-2:50	0.70	1.332	1.340	4.53
	4:00-4:05	0.58	1.182	1.187	3.82
	4:30-4:35	0.48	0.991	0.995	3.06
	4:55-5:00	0.33	0.700	0.702	2.03
Sept. 11[1]..	1:50-1:55	0.24	0.522	0.522	1.49
	2:20-2:25	....	0.347	0.347	0.95
	2:50-2:55	....	0.279	0.279	0.75
	3:20-3:25	0.24	0.508	0.508	1.47
	3:55-4:00	0.45	0.962	0.965	2.87
	4:45-4:50	0.62	1.240	1.246	4.07
Sept. 15[2]...	2:15-2:20	1.24	1.319	1.349	4.48
	3:00-3:05	0.92	1.001	1.014	3.14
	3:50-3:55	0.72	0.790	0.798	2.34
	4:25-4:30	0.50	0.529	0.533	1.53
	4:55-5:00	0.30	0.305	0.307	0.85
Sept 17[3]..	2:30-2:35	1.62	2.683	2.723	12.53
	3:05-3:10	1.39	2.279	2.309	10.18
	3:40-3:45	1.00	1.725	1.741	6.87?
	4:20-4:25	0.63	1.229	1.237	4.15?
	4:50-4:55	0.40	0.864	0.868	2.57
Sept. 18[4]...	1:55-2:00	2.87	2.603	2.733	13.38
	2:30-2:34	2.60	2.374	2.484	11.53
	3:05-3:10	2.01	1.915	1.977	8.31
	3:50-3:55	1.28	1.269	1.294	4.63
	4:35-4:40	0.75	0.773	0.782	2.45
Sept. 25[4]...	3:10-3:15	0.40	0.478	0.482	1.33
Sept. 26[1]...	1:43-1:45	0.47	0.491	0.493	1.42
	3:05-3:10	0.25	0.265	0.265	0.71
	4:10-4:15	0.13	0.120	0.120	0.36?
	4:40-4:45	...	0.101	0.101	0.24?
Sept. 29[5]...	3:15-3:20	0.42	0.249	0.253	0.13
	3:55-4:00	0.29	0.194	0.195	0.087
	4:25-4:30	0.18	0.149	0.149	0.051
	4:45-4:50	0.18	0.042	0.042	0.049
	5:05-5:10	0.08	0.022	0.022	0.021
Oct. 1[5].....	1:30-1:35	2.22	1.658	1.738	9.55
	2:10-2:15	1.90	1.189	1.249	6.91
	3:10-3:15	1.34	0.865	0.895	4.93
	3:45-3:50	0.92	0.581	0.593	3.14
	4:20-4:25	0.73	0.438	0.447	2.42

[1] Long weir, full depth. [2] Long weir, reduced depth. [3] Short weir, full depth. [4] Short weir, reduced depth. [5] Short weir, reduced depth. No. 2 orifices.

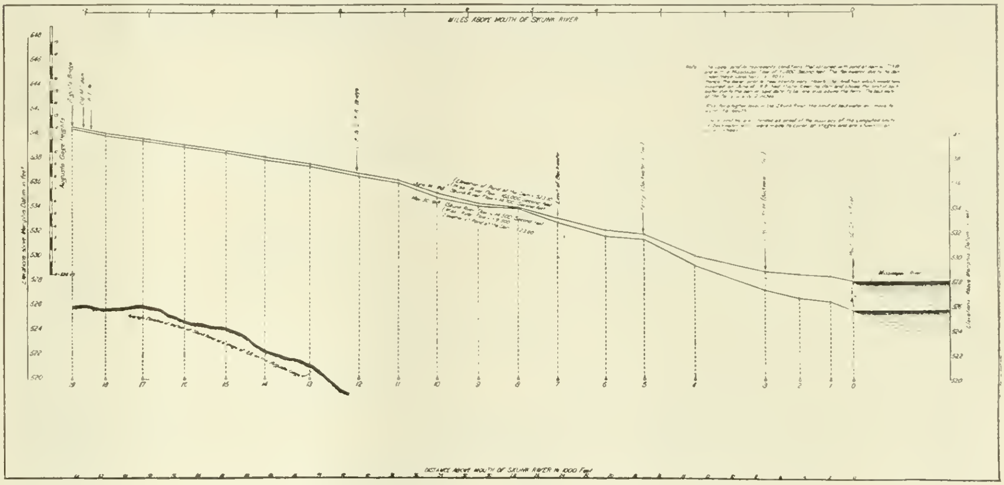
Method of Estimating Backwater on a River

The Skunk River is a stream some 300 ft. in width which empties into the Mississippi in the upper reaches of the lake created by the Kokuk dam. Its drainage, which lies in Iowa, is nearly 200 miles long and very narrow. In its lower reaches it flows with good velocity and in a continually shifting channel through some of the richest farm land of the country. Almost yearly, however, the stream goes out of its banks, spreading over many square miles of the flat bottom land. The Mississippi River Power Co. has a particular dislike for the river because, with the building of the Keokuk dam, the farmers affected by its rampages were only too ready to lay all their troubles with the river, at the power company's door. Not only this, but the sudden floods that drop from the river directly into the lake cause considerable uneasiness. Backwater from the Keokuk dam extends to Burlington, 40 miles above the dam, during high water, and further during very low water. The Skunk River enters the lake about 8 miles below Burlington and is affected by the dam by amount of backwater which varies from less than a foot at extreme high stages to several feet at very low stages. The fact that there was a certain amount of backwater from the dam at the mouth led farmers to believe that it was the cause of overflow even as far back as Augusta. Accordingly a complete survey was made of the 12-mile section between Augusta and the mouth of the river, and the limits of backwater defined. The investigation cost about $500. The methods employed and the results obtained are described by Mr. Albion Davis in the Stone & Webster Journal, from which the matter following is obtained:

The river drains 4,350 square miles of rather rough country. In its lower reaches it has an average width of 300 ft. and a slope of 1.3 ft. per mile. A characteristic of the river is its quick rise after rains and its well sustained flow for several days. Its flow, which is normally about 400 second-feet, has been as low as 100 second-feet and as high as 32,000 second-feet within the last few years. Two U. S. Geological Survey gaging stations are maintained on the river, one at Coppock, Ia., and the other at Augusta. The station equipment at the latter point consists of a standard chain gage attached to the down-stream handrail of the one and only highway bridge. Current meter measurements are made from the bridge for medium and high stages to establish what has proved to be a permanent flow rating curve due to the existence of the remains of an old mill dam a few hundred feet below the bridge.

The lower section of the river to which the backwater study was confined takes a rather sinuous course on its way to the Mississippi. The big bends in its course will be exaggerated on every flood until finally the loops will become so pronounced that a very high flood will cut across the neck of the loop and straighten the channel. This stretch of river is treacherous during flood. Full grown trees, dropped into the river when a bank is undermined, will go rolling easily down the river nearly as fast as the current. At one point that was noted particularly; two boats had been left high and dry on top of the bank tied to 8-in. cottonwood trees. Two mornings later the trees, boats, and all, including 6 ft. of the bank, were gone.

The problem to be solved seemed at first to be hopelessly complicated by the fact that the river was subject to backwater from the Mississippi before the dam was built, let alone the fact that the relation between stage and discharge was continually changing. These two facts precluded any attempt to compare conditions before the dam was built with those subsequent to its building. The solution was to be obtained by a careful analysis of present conditions followed by computation for the natural stages without the dam. This method would ordinarily leave some doubt as to accuracy because the final results depended on theory. In the case at hand, however, a happy coincidence of relative stages in the two rivers enabled an absolute check on the computed results. Profiles were obtained in the field which showed the actual limit of backwater precisely coincident with the computed limit for that particular stage.



River Profiles From Augusta to Mouth of River Showing Limit of Backwater.

The amount and extent of backwater from the Keokuk dam up the Skunk River is dependent, first of all, on the amount of backwater the dam causes at its mouth; secondly, on the stage of the Mississippi; and thirdly, on the stage of the Skunk River. The natural stage of the Mississippi causes a varying amount of backwater on the Skunk, depending on the stage of the latter. The dam adds its effect to this natural backwater.

The first part of the problem, namely, the effect of the dam at the mouth of the Skunk River, has been very completely worked out for all conditions of pond level and flow from original computations by J. R. Freeman in his admirable analysis of backwater in Lake Keokuk. Both the original computations by H. L. Cooper, and by J. R. Freeman have subsequently been borne out by the actual water levels. The same general method of analysis was used for the study of the Skunk River.

The remainder of the problem required the obtaining of field data involving soundings, several profiles and measurements of flow for low, average, bank full and extreme stages to cover the entire range of actual conditions. From these field data it was possible to compute the hydraulic elements for the individual reaches of the river between sections which were chosen so as to be about one-half mile apart. The method of computation was to first figure "c" in Chezy formula, $v = c\sqrt{rs}$, and then from it to figure the coefficient of roughness of channel bed "n" in Kutter's formulæ for "c."

$$c = \frac{41.65 + \dfrac{.00281}{s} + \dfrac{1.811}{n}}{1 + \left(41.65 + \dfrac{.00281}{s}\right)\dfrac{n}{\sqrt{r}}}$$

The next step was to obtain the profiles for conditions without the dam. To do this the coefficient of roughness was assumed to remain constant for the relatively small change of stage due to backwater and the new slopes then figured back from the mouth of the river, section by section, until the natural profile met the actual profile. Four actual and computed profiles were obtained covering in general all stages.

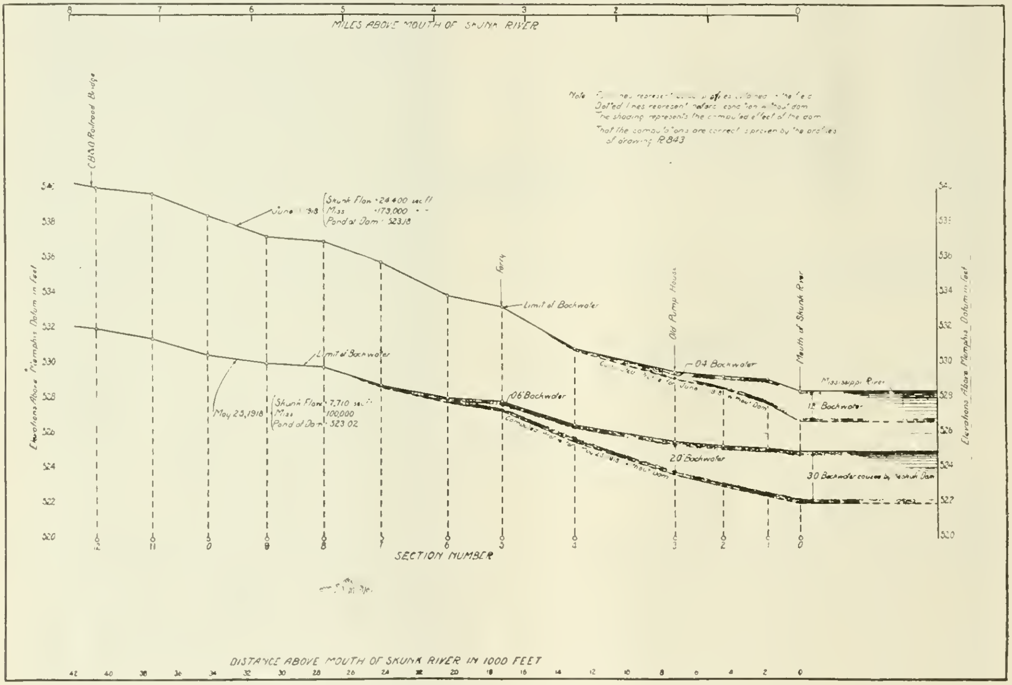
Although the above method of computation is laborious, it will be hard to find one which can improve on it because of the opportunity it gives to analyze the situation step by step and to make due allowances for irregularities of channel, obstructions to flow on the banks and effect of overflow. A number of general backwater formulæ have been developed, but have not come into extensive use because of the impossibility of making them fit the hopeless irregularities of the average river.

Field work for survey was started as soon as the river opened up in the spring of 1918. Fortunately, good contour maps of the lower section of the river were available. From these it was possible to obtain accurate channel distances without the necessity for a separate survey. The first step of the field work was to pick out the sections and locate them on the maps. Then bench marks and reference points were established at each section so that water elevations could be readily obtained by a single set-up of the level when making the profiles later. After the bench marks and sections were established, precise levels were run from the mouth of the river to Augusta, tying in all the bench marks on the way accurately.

While the river was still low, it was sounded at each section from a boat. A ¼-inch trot line was stretched clear of the water from bank to bank and so that it could be reached from the boat. Starting at the reference point on the bank 10-ft. intervals were laid off along the line by tape and a clothes pin set as a marker. Then soundings were taken with an ordinary level rod and the pins collected. This method was as accurate as using a marked wire which would not be subject to stretch and got away from the difficulties of handling a wire. The sections were next completed to elevations well above the highest floods by levels. The relative obstruction to flow offered by trees and brush in the overflow sections was estimated in the field at the same time so that close estimates of main channel flow could be made in the computations. In all, 19 sections were completed in this manner and plotted with full notes. Then the hydraulic elements were tabulated on the same sheet.

When the right stage occurred in the Skunk, a hurried trip was made to Augusta to obtain a flow measurement and a complete profile clear to the mouth. To have no question arise as to the accuracy of the flow rating curve at the Augusta gaging station, the current meter measurement of flow was made just before taking the profile. The flow measurements were made from the bridge with a Price current meter using piano wire for supporting the meter and 30 lb. of lead when necessary to cut down the drift of the meter. An average of about 30 measuring sections was taken with velocity observations at two-tenths and eight-tenths depth in each. Depths were measured in every section and corrected for drift where it was appreciable. Immediately after completing the flow measurement, water surface elevations were taken at each section in order downstream. The row boat used for transportation traveled downstream at practically the same rate as the current. This method of first taking the flow measurement and then working downstream on the profile, entirely eliminated any effect of change of stage due to time interval.

Fortunately, in less than three months all the desired stages had occurred and, in addition, there occurred an unusual combination of stages in the two rivers which practically duplicated a computed profile and proved its accuracy. This will be described later, however. The remaining work of the investigation involved mostly computing, the details of which will not be given here. The method of computing the natural profiles for each of the actual profiles obtained has been outlined above. It should be stated that the higher the stages are in the rivers, the less the backwater from the dam, and



River Profiles Showing Backwater Due to Keokuk Dam.

that, as the stages increase to flood, the limit of backwater moves downstream to within less than 4 miles of the mouth. This fact was quite a revelation to the farmers who were positive that the backwater extended nearly to Augusta.

The computations had proved very enlightening and were seemingly correct, but they still lacked absolute proof until on June 14, 1918, a combination of stages in the Mississippi and Skunk Rivers occurred which settled beyond a doubt the accuracy of the computations. On this date, after the Skunk River had fallen to a bank full stage practically the same as it had been on May 30th, the Mississippi was at its highest stage of the year. At this stage of the Mississippi, the backwater at the mouth of the Skunk was only 1.9 ft. In other words, if there had been no dam the flood level at the Sunk River mouth on June 14th would have been lower by 1.9 ft. This was almost exactly the Mississippi stage which had occurred on May 30th with the same stage in the Skunk as on June 14th. Hence a direct measure of the amount and extent of the backwater on June 14th was obtained which was free from theory and any uncertainties of shifting channel.

If the limit of backwater from this determination is compared with the computed limits, it will be found that there is absolutely no difference when effect of stage is considered. The obtaining of this profile was a source of great satisfaction. It shows the value of theory when applied with care and judgment.

The following tabulation of data is given in case other engineers care to compare or to use the coefficients computed:

Section No.	MEDIUM STAGE. Profile of May 25. Q = 7,710 second-ft.			BANK FULL. Profile of May 30. Q = 14.500 second-ft.			FLOOD STAGE. Profile of June 11. Q = 24,400 second-ft.		
	s	c	n	s	c	n	s	c	n
9......				.000135	85	.029			
8......				.000203	66	.035			
7......				.000316	66	.036			
6......	.000124	84.4	.027	.000180	79	.031	.000340	74	.033
5......	.000188	67.9	.032	.000287	54	.044	.000382	55	.045
4......	.000246	67.2	.034	.000426	62	.038	.000399	77	.030
3......	.000124	75	.031	.000286	69	.034	.000168	91	.026
2......	.000064	100	.023	.000168	95	.024	.000088	128	.018
1......	.000076	88	.027	.000242	78	.030	.000194	78	.031

It will be noted that there appears to be a definite increase in the coefficient of roughness with an increase of flow up to a bank full stage. With further increase of stage, however, the coefficient remains about constant. This may be due to the fact that the flow in the overflow sections was estimated separately from the open channel flow, thus eliminating the excessive friction which would be erroneously indicated if the overflow were considered as a part of the main channel flow. The river channel is of sand and silt with banks of heavy loam. Trees and brush line the top of the banks, their amount and extent increasing from the railroad to the mouth until, at the mouth, the entire overflow section is wooded.

One point clearly brought out by the study was the excellent opportunity afforded for a study of backwater where two streams, whose crests of flow do not come at the same time, meet. Such a situation allows of the obtaining of actual backwater values directly. Methods of computing backwater as well as backwater formulæ can be very readily tested out in such a location.

Water Purification in Ohio

Some 285 public water supply installations have been made for Ohio municipalities and unincorporated communities having a present population of approximately 4,000,000. This represents 93 per cent of the total population of the municipalities of the state and 74 per cent of the total population of the state. Sixty-nine water supply installations use water of surface origin and serve a population of 2,800,000; 12 use surface water in connection with ground water supplies and serve a population of 300,000; and the remaining 205 installations use ground water from wells, springs and similar developments and serve a population of 900,000.

This information was presented by W. H. Dittoe, Chief Engineer, Ohio State Department of Health, in a paper read before the 47th annual convention of the American Public Health Association at New Orleans. The paper outlines chiefly the activities of the State Department of Health in supervision of water purification plants in Ohio. The following abstract of the paper emphasizes the need for adequate control:

Of a total of 81 water supply installations using surface water, in whole or in part, and serving a population of 3,100,000, 51 have filtration plants, 9 employ chlorination as the only process of purification, and 21 employ no treatment. The filtration plants serve a population of 2,700,000, the chlorination plants a population of 300,000, and the untreated surface supplies a population of 100,000. It will be noted that the purity of the water supplies serving a population of 3,000,000 is dependent upon the efficiency of treatment processes, and as this population is 56 per cent of the total population of the state, it is apparent that a most important duty rests upon the State Department of Health to secure operation and maintenance which will insure the constant production of water satisfactory for domestic use.

The total number of filter plants in the state is 51, with a total daily capacity of 502,000,000 gal. Of these, 21 plants are now under constant supervision of a technical superintendent, 22 have intermittent technical supervision and 8 are operated without any technical supervision or analytical control. Reports are now received from 47 of the plants, including 4 of the last class. The 8 plants which receive no technical supervision vary in capacity from 100,000 to 800,000 gal. per day and have a combined capacity of only 3,500,000 gals. Of the 9 disinfection plants in operation 8 are under intermittent technical supervision with analytical work to check efficiencies.

The experience of the department in connection with the control of operation of water purification plants has led to the adoption of certain guiding principles which are as follows:

Every filtration or disinfection plant should have some degree of technical supervision, and filter plants having capacities of 1,000,000 gals. per day or more should be under daily technical supervision. The superintendent of filtration, whether employed constantly or intermittently, should be given full authority over the plant and other plant employees. As the problem is principally plant operation and maintenance, the employment of an analyst to examine samples and act in a merely advisory capacity does not provide efficient supervision.

The superintendent of filtration should be qualified by training in water supply engineering, chemistry and bacteriology, and when employed for the larger plants, should have had experience in the operation of a smaller one. In rare instances it is possible for a man to become qualified by experience without fundamental technical training.

In passing upon the operating results of a water purification plant the efficiency of each individual process should be considered independent of the next succeeding process. Coagulation must be efficient to prevent excessive load on filters. When daily technical supervision is not provided, a factor of safety must be furnished by using constantly a quantity of coagulant as specified by the department in excess of that which would otherwise be required. The rate of operation of gravity rapids and filters should not exceed 125,000,000 gal. per acre per 24 hours, and if this rate is exceeded, filter efficiency suffers. Disinfection should be applied to filter effluents and must be a true factor of safety.

The final effluent of the purification plant must show negative presumptive tests for B. coli in at least 80 per cent of all samples collected throughout the month. If the construction of the purification plant will permit, this standard is applied to the effluent of the filters before disinfection, in which case disinfection becomes a true factor of safety.

Convention of American Concrete Pipe Association.—The American Concrete Pipe Association held its annual convention in Chicago, Feb. 20 and 21. The following officers were elected for the coming year: President, A. N. Shearman, Knoxville, Tenn; vice presidents, Ernest Bent, Los Angeles, Calif.; Harry K. Cain, Mankato, Minn.; A. M. Hirsh, New York City; manager, G. E. Warren, 210 South LaSalle Street, Chicago. The association membership has increased and a new office in Chicago will be opened, with sufficient help to conduct the larger activities of the association.

Annual Meeting of New Jersey Sewage Works Association.—The New Jersey Sewage Works Association, which held its annual meeting at Trenton, N. J., Feb. 26, elected the following officers: President, Chester G. Wigley of Maplewood, formerly connected with the Department of Health as water and sewage engineer; S. Fischer Miller of South Orange and John R. Downs of Plainfield were elected vice presidents, and Frederick T. Parker of Atlantic City was re-elected secretary-treasurer.

POWER AND PUMPING SECTION

This section of the Waterworks and Hydraulic Monthly issue of Engineering and Contracting is devoted to the selection of power and pumping equipment and the economic management of its operation.

Storage of Bituminous Coal

Useful suggestions on the storage of bituminous coal were given by H. H. Stock, Professor of Mining Engineering at the University of Illinois, in a paper presented some months ago before the Western Society of Engineers. The following conclusions are based on a study of several storage plants and also constitute a digest of opinions obtained from a questionnaire sent to a large number of men who have had practical experience in storing coal:

Kind and Sizes of Coal That Can Be Stored.—Although it is undoubtedly true that some coals may be stored with greater safety than others, the danger from spontaneous combustion is due more to improper piling coal than it is to the kind of coal stored.

Most varieties of bituminous coal can be stored in the air if of proper size and if free from fine coal and dust. The coal must be so handled that dust and small coal are not produced in excessive amounts during the storing, because spontaneous combustion is due mainly to the oxidation of the coal surface.

All varieties of bituminous coal can be stored under water which excludes the air and prevents spontaneous combustion.

The danger of spontaneous combustion in storing the coal is very greatly reduced if not entirely eliminated by storing only lump coal from which the dust and fine coal have been removed. Of two coals the least driable should be chosen for storage purposes, because less dust and fine coal will be produced in its handling.

By preventing air currents through the pile by means of a closely sealed wall built around the pile.

By closely packing the fine coal. Such a coal pile must be closely watch for heating. Piles of slack must be very closely watched for heating and means provided for promptly moving the pile if heating develops. The only absolutely safe way to store slack or fine coal is under water.

Fine coal or slack has sometimes been successfully stored:

Many varieties of mine run coal cannot be stored safely because of fine coal and dust mixed with the lumps.

Coal exposed to the air for some time may become "seasoned" and thus may be less liable to spontaneous combustion, due to the oxidation of the surface of the lumps of coal, but opinions are by no means unanimous upon this point.

It is believed by many that damp coal stored on a damp base is peculiarly liable to spontaneous combustion, but the evidence on this point is by no means conclusive. It is safer not to dampen coal as or after it is placed in storage.

Effect of Sulphur on Spontaneous Combustion.—It has been shown by experimentation that the sulphur contained in coal in the form of pyrites is not the chief source of spontaneous combustion, as was formerly supposed, but the oxidation of the sulphur in the coal may assist in breaking up the lumps of coal and thus increase the amount of fine coal, which is particularly liable to rapid oxidation. Even this latter opinion is not unanimously endorsed. In spite of experimental data showing that sulphur is not the determining element in spontaneous combustion, the opinion is very widespread that, if possible, it is well to choose a coal with low sulphur content for storage purposes.

Method of Piling Coal.—To prevent spontaneous combustion coal should be so piled that air can circulate through it freely and thus carry off the heat due to oxidation of the carbon, or else it should be so closely piled that air cannot enter the pile and oxidize the fine coal.

Stratification or segregation of fine and lump coal should be avoided since an open stratum or a chimney of coarse lumps of coal gives a passage for air to enter and comes in contact with fine coal and thus to oxidize it and start combustion.

If space permits, low piles are preferable, as the coal is thus more exposed to the air and better cooled than in high piles and in case of heating it can be more readily and quickly moved. A disadvantage in high piles is the greater difficulty of moving the coal quickly, if necessary. The idea that a high pile causes heating at the bottom is erroneous, since as many fires take place near the top as near the bottom and near the outside as near the interior of the pile. If possible the coal pile should be divided by alley-ways so as to facilitate rapid loading out of the coal in case of necessity so that the entire coal pile may not be endangered by a local fire.

Much of the attempted ventilation of coal piles in the United States has been inadequately done by the use of only an occasional ventilation pipe which has been not much more than a place in which to insert a thermometer for reading temperatures. The practice is not advised. The practice of placing ventilating pipes close together has been used in Canada and is reported to have been effective.

Water is an effective agent in quenching fire in a coal pile if it can be applied in sufficient quantities to thoroughly cool and put out the fire, but a small amount is ineffective. Unless there is an ample supply of water to thoroughly quench the fire and cool the pile, it is very dangerous to add any water to a coal pile.

Coal of different varieties should not be mixed in storage if this can be helped, for one coal that has a greater susceptibility to spontaneous combustion than the other may jeopardize the safety of other coals that are not so liable to spontaneous combustion.

Effect of Storage on Value of Coal.—The heating value of a coal as expressed in B. t. u. is decreased very little by storage, but the opinion is very widespread that storage coal burns less freely when fired in a furnace. Experiments indicate that much of this can be overcome by keeping a thinner bed on the grate than is kept with fresh coal and by regulating the draft.

The coking properties of most coals seem to be decreased as a result of storage.

The deterioration of coal stored under water is negligible, and such coal absorbs very little extra moisture. If only part of a coal is submerged, the part exposed to the air is still liable to spontaneous combustion.

Additional Precautions in Storage of Coal.—The best preventive of loss in coal storage is to regularly inspect the pile and if heating occurs up to 150° F. to keep very close watch on the pile and if the heating increases to 175° or 180°, to remove the coal as promptly as possible from the spot affected, and thoroughly cool it before piling it again.

Storage appliances and arrangements should be so designed so as to make it possible to load out the coal quickly if necessary, and the coal should not be stored in large piles unless provision is made for loading it out quickly.

Pieces of wood, greasy waste, or other easily combustible material mixed in a coal pile may form a starting point for a fire, and every effort should be made to keep such material from the coal as it is being put in storage.

It is very important that coal in storage should be kept from such external sources of heating as steam pipes, because the susceptibility of coal to spontaneous combustion increases rapidly with an increase in temperature.

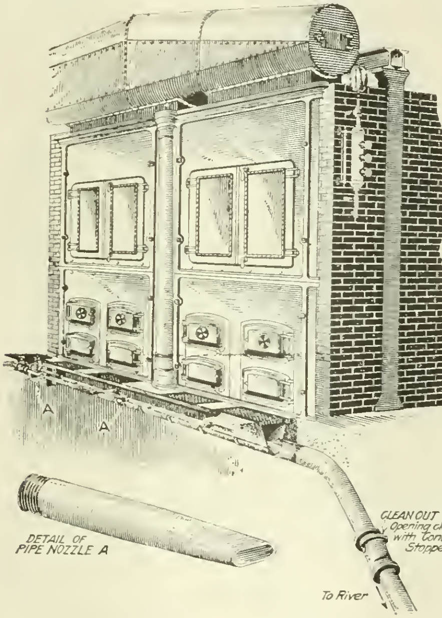
"The Lord of the Garbage Can."—Garbage collectors in Berlin, according to a press dispatch are now earning more than university professors and much more than minor officials in the foreign office and the other ministries. If one has a wagon and two horses he makes 9,906 marks a year, plus his tips which amount to as much more. He has become a tyrant, and will remove no garbage unless he receives fees. The Berlin papers speak of him as the "Garbage Lord."

Ash Removal by Sluicing

An ingenious sluicing system used in a small electric light plant for disposing of ashes is described in Power.

The installation consists of two 72-in. x 18-ft. return-tubular boilers that have two fire-doors each and are hand-fired with the usual run of small coal. The ash content of the coal varies from 15 per cent to 25 per cent, and naturally there is a fairly large quantity of ash.

Previous to the installation of this equipment the ash was handled by means of wheelbarrows, entailing considerable expense. The arrangement illustrated consists merely of a sluicing trough of concrete across the front of the boilers, the bottom of the trough being lined with semicircular vitrified-tile pipe. A water jet is placed in front of each boiler in the position shown, and is fitted with the necessary operating valve.



Sluicing Arrangement in Front of Boilers for Ash Disposal.

The ash duct is covered by small concrete slabs, except in front of each ashpit door, where a cast-iron grating is located. The ashes are sluiced down by means of the water jet, and a 10-in. vitrified-tile pipe is connected to the end of the trough and carried away to the place where the ashes are to be deposited—in this case to the bank of a near-by river. Clean-out Y's are placed in the line of tile pipes to facilitate the removal of obstructions that may occur.

The trough is given a fall of ½ in. per foot, which is found in practice to be quite ample to carry away clinkers of any reasonable size. This slope could be varied from ¼ in. per foot to ¾ in. per foot, as desired. Quick-opening valves are desirable, although not absolutely necessary.

The cast-iron grating is provided with a sheet-steel cover that is held to the grating by means of two straps fitted to hinge pins cast into the grating, so that the cover may be lifted from either side or removed entirely when desired. In the case of hand-fired boilers it is desirable that the gratings be covered when the boilers are fired, to prevent the loss of coal due to spillage. When raking ashes from the ashpit, the cover would be lifted toward the fireman, so that the ashes could be raked on to the grating.

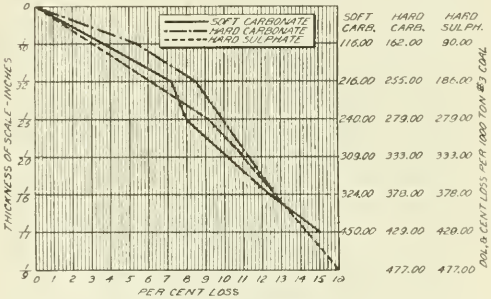
Any large clinkers that are pulled out of the ashpit have to be broken through the grating. This does away with pieces of clinker too large to be carried off by the sluicing trough. The ribs of the grating are made with the upper edges tapered in order to facilitate the breaking of the clinker.

Heat Loss Due to Scale on Boiler Heating Surfaces

The accompanying chart, reproduced from Power Plant Engineering, is based on the results of carefully conducted experiments made at the University of Illinois to determine the heat loss due to scale. The tests were not made on scale thicknesses beyond 1/9 in., primarily because greater thicknesses are not found in any half way up-to-date plant. The chart was compiled by Mr. F. F. Vater, who comments on it as follows:

This chart shows that in a thin, hard carbonate scale the heat loss is greater than if the scale were a thin, hard sulphate or a thin, soft carbonate. It also shows that a soft carbonate scale up to 1/32 in. thick causes a greater heat loss than a hard sulphate scale of like thickness, but a less loss than a hard carbonate scale of equal thickness. It shows that the hard carbonate scale causes a greater heat loss than a hard sulphate or a soft carbonate scale when the scale is 1/25 in. thick or less, and that from 1/25 to 1/9 in. the heat loss is practically the same on a hard scale whether it be of carbonate or sulphate character.

We are strong believers in the dollar and cent showing in a chart of this kind because so many men look at the percentage without figuring out the ultimate loss. They are prone to think that 3 or 5 per cent is not much and let it go. It is the extensions of these small percentages that contain the surprises.



Heat Loss, Due to Boiler Scale.

In the extension we have shown the dollar and cent loss based on $3 coal, 1,000 tons burned. This showing can easily be converted to any tonnage or any price coal. For instance, if a plant burns 10,000 tons a year and pays $4 a ton, its scale is a hard carbonate 1/16 in. thick. By referring to the chart, we find the dollar and cent loss per 1,000 tons, $3 coal, is $378; $4 coal is 1/3 more, hence, 1,000 tons of $4 coal means $504 lost, and 10,000 tons $5,040 lost.

Again, in a plant having a hard carbonate scale, 1/32 in. thick burning 10,000 tons a year, $4 coal, the loss is $3,400. This is a sum justifying (on a 16 per cent gross basis) an expenditure of $21,250 to overcome or prevent this loss.

We all know that the scale thickness varies in any type of boiler. In the fire tube type there is more scale at the rear than at the front end; that the scale will be thicker on the tubes than on the shell; in the water tube type of boiler there will be more scale in the middle and bottom rows of tubes than in the top rows. To make the chart most valuable, the average thickness should be closely approximated.

Mosquito Extermination in New Jersey Would Increase Taxable Values $500,000,000.—The absolute extermination of the salt marsh mosquito in New Jersey is practicable and opens the way for an increase of more than $500,000,000 in taxable values of the state to be achieved within a period of 20 years, according to a report of Dr. Thomas J. Headlee, state entomologist of New Jersey, submitted Feb. 5 to the New Jersey Mosquito Extermination Association's Convention. The report fixes the probable cost of draining the 260,000 acres of salt marsh at $900,000, instead of $750,000, as formerly estimated. It shows an increase in valuation of the Newark meadow from $650 in 1896 to $238,513 in 1919 in consequences of mosquito extermination, making large areas of marsh available for factory sites and other commercial purposes.

Compounds for Treating Boiler Water*

By W. S. MAHLIE.

Boiler compounds are of many different compositions, some good, some bad, some indifferent. All boilers are not alike, neither are all boiler waters. For this simple reason no compound can be developed which is a sure cure for all boiler troubles. Some may be good for one thing, some for another.

In view of the many compounds sold, it has been undertaken in a general way to show their classes, possible reactions, and other data, and let the buyer of the compound judge for himself as to their merits.

A successful boiler compound must fill the following requirements: (1) It must make the water non-corrosive. (2) It must hold in suspension, or colloidal form, all of the salts which would give rise to an incrusting precipitate. (3) It must put the water in such a condition as to keep it from foaming or priming. (4) It must be a chemical or compound of such a nature that it can be safely stored and kept from deteriorating. (5) It must be of such a nature that it can be easily measured or weighed and applied. (6) Its cost must compare favorably with other methods of feed water treatment.

Compounds are generally used for either one or more of the three following purposes: First. To remove and prevent scale. Second. To prevent corrosion. Third. To prevent foaming. Only compounds of the first and second kinds will be considered here because, strictly speaking, the third kind are not boiler compounds, but anti-foaming compounds.

The boiler compounds may be roughly divided into three classes: 1. According to chemical action. 2. According to mechanical action. 3. According to combined chemical and mechanical action. In the following discussion the terms temporary hardness and permanent hardness will be used, denoting respectively the bicarbonates of lime and magnesia; and the sulphates, chlorides and nitrates of lime and magnesia. The term incrustants is usually applied to the latter, but most practical men prefer the term permanent hardness.

Soda ash or sodium carbonate is used more than any other chemical and is the base for practically all boiler compounds. Soda ash usually runs about 98 per cent pure sodium carbonate (Na_2CO_3). Another form known as soda crystals runs about 34 to 35 per cent (Na_2CO_3), the balance being water of crystallization.

The action of soda ash in the boiler is the same as in the regular treating plant outside the boiler. It removes the hard scale or permanent hardness, and neutralizes acids which cause corrosion. Too much soda ash should be guarded against, as it will cause foaming when used in excess.

Sodium silicate or water glass is coming into extensive use as a boiler compound. It is seldom applied alone, but most always in combination with soda ash or tannin. Sodium silicate has the advantage of acting on both temporary and permanent hardness. When sodium silicate acts on temporary hardness one part of soda ash or sodium carbonate is liberated for each part of silicate added; this sodium carbonate is then available to act on permanent hardness. In using sodium siliciate the same precautions should be used as in all sodium compounds, since excesses cause foaming. Sodium silicate comes to the market in liquid form.

Sodium hydrate or caustic soda is not used as much as formerly, when it had quite an extensive use. Caustic soda acts on both temporary and permanent hardness and neutralizes acids. Like sodium silicate in its action on temporary hardness, each part of it liberates an equal amount of sodium carbonate available for action on the permanent hardness. Caustic soda is not available for removing sulphates of lime and magnesia alone, without the presence of enough temporary hardness, since by the action of caustic soda, hydrates of lime and magnesia are formed.

An excess of caustic soda is probably one of the worst things to get into a boiler, because, like other soda salts, it causes foaming, and has a decided action on brass valves and fitting. Caustic soda is bad material to handle, since it takes up water very readily from the air and burns the skin and clothing. Caustic soda is sometimes mixed with soda ash and is known as Special Alkali. The approximate composition of this material is 40 per cent caustic soda and 60 per cent soda ash.

Tri-sodium phosphate was formerly used to a great extent, but is not used so much at present. It is distinctly a boiler compound since the reactions between lime and magnesia compounds are not complete at ordinary temperatures, but the water must be boiled in order to obtain the maximum effect. Like the silicate and hydrate of sodium in its action on temporary hardness it liberates an equal part of sodium carbonate, which can be available for further action.

The di-sodium has also been used as a boiler compound. The precipitates or sludge obtained from the action of the phosphates are very light and flocculent, and are easy to blow out of the boiler. It is claimed by some that sodium phosphates are the most efficient boiler compounds in use.

Sodium chromate can be used to precipitate lime compounds, temporary and permanent. Another peculiar property of chromates is that they render iron passive to corrosion.

Sodium borate or borax has been used to some extent as a boiler compound. Lime compounds are precipitated cold, as borates, but magnesia compounds are only precipitated under the heat of the boilers.

In all the preceding discussion, sodium compounds only have been considered. It should be remembered that potash compounds will act in a similar manner, but owing to the high price of potash compounds they are not used for this purpose.

Barium Salts. In many respects the barium compounds are the ideal boiler compounds, since no soluble alkaline salts are left in solution by their use. On the other hand, their cost is much greater, due to the larger amounts required for reactions, and also to the increased cost per pound compared with an equal weight of sodium compounds. In addition, barium salts are poisonous and consequently are not desired, even around boilers, where anyone might accidentally drink some of the water. Barium salts are ideal for incrusto-corrosive waters having high sulphate content, which otherwise would cause foaming by treating with sodium compounds.

Lime. Lime reacts on the free acids, temporary hardness and magnesium compounds. The introduction of lime, however, adds a very bad feature to the acid waters, inasmuch as it will give rise to an extremely hard scale, and the acid is only removed or neutralized at the expense of adding hard scale to the boiler.

Lime comes to the market in two forms, the lump or quick lime, and the hydrated lime. The lump lime is usually the cheapest and an equal weight of it is more efficient than the hydrated lime, since the hydrated lime contains about 25 per cent of combined water. The lump lime, however, becomes air slacked on exposure to air, and is then useless for water softening, while the hydrated lime does not slake. Lump lime runs about 88 per cent pure. When only small amounts of lime are used, the hydrated is probably the best to use, since it can be stored and does not slake. Lime acts on all free acids, on temporary hardness and on magnesium compounds.

Tannin Compounds and Wood Extracts. Tannins are used as scale preventives in boilers. They are distinctly boiler compounds, and precipitate lime and magnesium as a light bulky precipitate. Tannins are seldom used alone, usually combined with sodium carbonate, sodium hydrate or sodium silicate. Tannins are obtained from a great many sources, some of them being hemlock bark, oak bark, Canaigre, Quebracho, Palmetto root, Catechu, Gallnuts, Sumac, Valonia and Divi-Divi.

When tannin is used it leaves a very light friable deposit, which is easy to remove. It is claimed that tannins are among the safest and best materials to put into a boiler. Some persons object to tannin, claiming that it will cause corrosion. No cases of such action, however, have been brought to light. The different bark extracts are mixtures of tannin and other closely related materials which act in a manner similar to tannin.

Sugar and Molases, Glycerine. It has been claimed that sugar, molasses and glycerine are good scale preventives, that they dissolve the lime and magnesia salts and hold them in solution, thus preventing a deposit. But a series of scientific experiments have proven the fallacy of using sugar and molasses for this purpose.

Clay. De La Coux says: "Clay is a fairly good scale preventive, but there is danger of it working into the machinery." It would appear to be a rather peculiar proceeding to add clay to boiler water, because most boiler waters contain clay and other suspended material which it is desired to remove.

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*Abstract of paper presented before the Western Railway Club.

Talc, powdered limestone or chalk, pumice and ground glass would all act in a manner similar to clay. No advantage can be seen in the use of any of these since they all are inert chemically and they are not of a nature which would benefit scale by being incorporated with it.

Graphite. Literature on the use of graphite as a boiler compound is very scanty. After a thorough search, numerous instances were found where graphite was used, but no record of the results obtained were shown. Graphite cannot be used other than from a mechanical standpoint in removing scale, since it is inert at ordinary temperatures. The producers of graphite say graphite will not act chemically, but when the scale is deposited the graphite intermingles with it and prevents it from becoming a compact mass, and keeps it soft and easy to blow out. They also say that the graphite will work through the accumulated scale to the tubes and shell of the boiler and loosen the deposited scale. It is doubtful whether the graphite will do this, but if the graphite were coated on the inside of a new boiler, it would prevent much scale from adhering to it.

Starch, Glucose, Dextrine, Potatoes, Slippery Elm, Artichokes. Any number of materials of a similar character have been proposed. Their action, if any, is entirely mechanical. It is claimed that these substances dissolve in the water and form a sort of gummy gelatinous coating around the grains of deposited scale and prevent them from sticking so tightly together.

Dextrine, starch and glucose are more frequently used as binders in boiler compounds to hold the different constituents together, either in the shape of a ball or a brick.

Ground hoofs and horns have been used to prevent scale. When boiled these would yield glucose and gelatines which would act as before stated.

Oils. The addition of oil to a boiler to prevent scale has been practiced for a long time. The action, of course, is entirely mechanical. Several explanations as to the action have been made. Some say the oil "rots" the deposited scale. Others say the oil envelopes the precipitated scale and prevents it from sticking. Others say the oil is attracted to the hot tube, becomes overheated, and forms a tiny explosion, which breaks or knocks off the deposited scale. The benefit of oil addition appears to be questionable.

Fats. Fat either alone or mixed with other substances has been proposed and used. It was probably the intention to coat the inside of the boiler with a coating of grease to prevent the particles of scale from adhering to the inner surfaces. No cases have been found recorded where this was entirely satisfactory.

Rosin and Tar. Rosin has been used in a manner similar to fats. When tar was used it was mixed with five parts of oil before being applied.

Before going into the use of a boiler compound on a large scale, the composition of the compound should be ascertained, and its value in removing the scale and acid materials should be determined. The cost of the compound should be compared with the cost of treatment with lime and soda ash in a regular treating plant. The labor in applying the compound should also be compared with the labor of operating a regular treating plant.

WHOLESALE PRICES OF CHEMICALS IN EFFECT JAN. 1, 1919.

Lime, 88 per cent, ton	$11.05
Soda ash, 98 per cent, ton	58.60
Caustic soda, 76 per cent Na_2O, cwt	4.15
Sodium phosphate, lb	0.04
Sodium silicate, 40 deg. Baume, lb	0.02
Barium hydrate, 54 per cent, lb	0.18
Barium carbonate, 97 per cent, ton	65.00
Barium chloride, ton	70.00
Borax, lb.	0.08¼
Tannic acid (commercial), lb.	0.65

In all cases lowest quotations are given.

It should also be remembered that when using a boiler compound, the only way in which the scale can be removed is by blowing down. Blowing down wastes water and steam which has been brought to boiler temperature at the expense of coal.

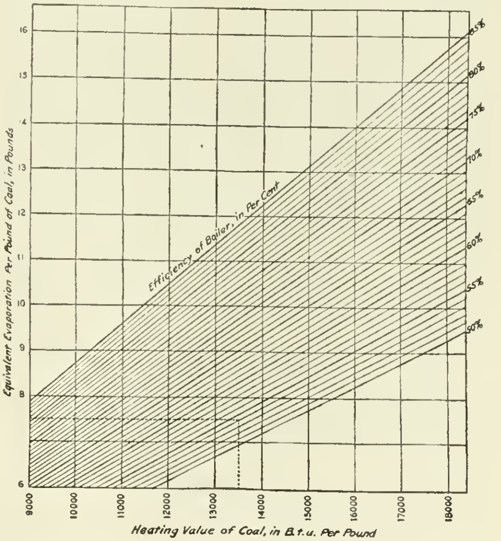
Public Improvements in Peru. The Peruvian government has announced a program of public improvements that calls for the construction of a mole and a floating dock in Callao, the development of a new port at Matamari, the construction of a system of railroad lines across the country, one in particular to connect Callao and Iquitos, and the construction of a water-system for Lima, already begun under the supervision of an American engineer.

Chart for Determining Boiler Efficiency

If the equivalent evaporation per pound of coal is calculated and the heating value of the coal is known, the boiler efficiency may be found directly from the accompanying chart, reproduced from Technical Paper 120, of the U. S. Bureau of Mines. At the left-hand side locate the point corresponding to the equivalent evaporation and at the bottom locate the point corresponding to the heating value of the coal. Follow the horizontal and vertical lines from these two points until they cross, and note the diagonal line that is nearest to the crossing point. The figures marked on the diagonal line indicate the boiler efficiency.

For example: The equivalent evaporation is 7.5 lb. and the heating value of the fuel is 13,500 B. t. u. At the left of the chart locate the point 7.5 and at the bottom locate the point 13.500. Then follow the horizontal and vertical lines from these two points until they cross, as indicated by the dotted lines. The crossing point lies on the diagonal corresponding to 54, and so the efficiency is 54 per cent.

The chart also can be used to indicate the evaporation that should be obtained in order to reach a desired efficiency. Suppose, for example, that it is desired to know how much water per pound of coal must be evaporated to produce a boiler efficiency of 65 per cent with coal having a heating value of 13,500 B. t. u. per pound.



Evaporation Chart.

Locate 13,500 at the bottom of the chart, follow the vertical line until it meets the diagonal marked 65 per cent, and then from this point follow the horizontal line to the left-hand edge, where the figure 9 is found. This means that the equivalent evaporation from and by 212° F. per pound of coal must be 9 lb. of water. If the steam pressure is 100 lb. gage, and the feed-water temperature is 180° F., the factor of evaporation is 1.0727, then the actual evaporation must be $9 \div 1.0727 = 8.36$ lb. per pound of coal. In other words, to increase the efficiency from 54 per cent to 65 per cent under the same conditions of pressure and feed-water temperature, it would be necessary to increase the actual evaporation from 7 lb. to 8.36 lb. This would mean practically 20 per cent more steam from the same weight of coal used.

$8,000,000 Irrigation Project in Australia.—Work is now under way on an $8,000,000 irrigation project in New South Wales. The project will have a reservoir capacity of 1,000,000 cu. ft., and reservoir area of 30,000 acres. The main dam, across the Murray River, will be 3,601 ft. in length, consisting of a 2,700 ft. earth section, a 740 ft. concrete spillway and a 1,060 ft. outlet works. A portion of the 100,000 cu. ft. per second discharge over the dam will be utilized for a hydroelectric development. The project also includes an irrigation canal, and construction of locks and dams for control of the Murray River.

SCIENCE OF MANAGEMENT

Application in Civil Engineering and Construction Fields

The term Science of Management was coined by the editor of Engineering and Contracting and first used in "Cost Analysis Engineering" (1908) and explained more fully in "Cost Keeping and Management Engineering" (1909). The last named book, which contains ten laws of management and many subsidiary principles, was the first book on the science of management. In the columns of this journal many additional laws, principles and detail methods of management have been published. This section, which appears weekly, may be regarded as a serial sequel to the two books above named.

Employes' Representation Plans in American Industries

An interesting resumé of the methods adopted by several large American concerns in applying the self-government plan for solving internal industrial problems was given by Mr. Percy E. Barbour in a recent issue of the Journal of the Worcester Polytechnic Institute. An abstract of the paper follows:

The Bethlehem Steel Plan of Direct Dealing with Employes.—At the plant of the Bethlehem Steel Co., under prewar conditions there were 40,000 employes. This was increased to 130,000 during the war. This large increase made necessary a step which the company had long had in mind, namely the inauguration of some direct method of dealing with the employes on industrial questions. It was finally decided to adopt a plan whereby the employes should elect, by districts in the plant, representatives who were to organize and choose their own officers and to appoint committees to take up with the management the questions which directly affected the employes.

The pertinent features of the plan adopted are:

1. Representation by units on the basis of the number of employes in each plant.
2. Nominations and elections for representatives by secret ballot.
3. Specific qualifications for voters and representatives.
4. Provision for the organization of committees.
5. Provision for regular monthly meetings of committees.
6. Provision for joint committees of an equal number of employes' representatives and management's representatives.
7. Provision for joint committee meetings on alternate months.
8. Provision for a logical and expeditious procedure for adjustment of matters arising for settlement.
9. Provision for protection of the employes' representatives against discrimination.
10. Provision for amendments to the plan.
11. Does not abridge the employe's right to belong to labor unions.
12. Provision that company officials and persons having the right to hire and discharge are not eligible as representatives or qualified to vote.
13. Provision for rotating representatives, every six months one half of the total number being elected to serve one year. By this method there is always one half of the representatives holding over, who are familiar with the work.
14. Provision for compensating representatives for time occupied in attending meetings.
15. Provision for management's representative who keeps the management in touch with the employes' representatives and represents the management in negotiations. Helps to remove difficulties, prevents misunderstandings and facilitates smooth operation of the plan in general.

During the six months this plan was in operation, many matters were settled without any friction whatsoever. Provided this channel for the discussion of matters, an adjustment could be arrived at before becoming controversial in the slightest degree. Of 250 cases settled through the representatives about 85 per cent were settled in favor of the employes.

The success of the plan may be attributed to the fact that the management has been absolutely sincere in the work and the representatives have approached the many matters that have come to their attention in a fair and open-minded manner. Their recommendations have been along constructive lines and they have shown a marked appreciation of the problems with which the management has had to deal. This is largely due to the caliber of the representatives elected. They were for the most part chosen from the older employes in point of service and were men of a very high grade, many of them having been in the employ of the company from 15 to 25 years. They have exercised an influence for good among the employes, creating an esprit de corps which is so desirable and necessary to the success of any enterprise.

The logical approach to the introduction of a plan of employes' representation or any other innovation is first to decide the necessity. Having decided that employes' representation is desirable, the following principles might be considered as fundamental, varying of course to suit local company and community conditions.

1. Method of Inauguration. Start with an invitation to employes to select representatives from their own number with whom details of a plan or agreement may be worked out.
2. Unit of Representation: The units of representation, or constituencies, should be departmental or in accordance with shop divisions. A sufficient number of representatives should be elected so that all employes may be adequately represented.
3. Method of Election: Election of representatives should be held in the plant at least annually. Representatives should be chosen by secret ballot, with such safeguards as to insure a free and untrammeled choice.
4. Qualification of Voters and Representatives: Careful study should be made to determine, in view of local conditions, whether there should be reasonable limitations of the privilege of voting and of eligibility for election as representatives.
5. Personnel and Scope of Joint Conferences: All matters of joint interest, such as hours, wages and working conditions, and the adjustment of grievances should be discussed and adjusted in joint conferences where the employes' representatives meet an equal or less number of representatives of the management. Frequent conferences are desirable for the consideration of constructive subjects of mutual interest.
6. Provision for Appeal: Provision should be made for prompt reference to the chief executive of the company of any matters that fail of adjustment in joint conferences.
7. Guarantee against Discrimination: There should be no discrimination against any employe on account of membership or non-membership in any labor organization.
8. Executive Supervision: A representative of the management should be responsible for carrying out the policy of the company in matters affecting industrial relations and in safeguarding the rights of the employes. This should be done without relieving plant executives of their responsibilities in these vital matters.

The Rockefeller Industrial Plan.—About four years ago the Colorado Fuel and Iron Company, one of the largest industrial corporations of the state of Colorado, inaugurated a new industrial plan. It is based on the principle of representation of the employes in the technical management of the plant and includes adequate machinery for the uncovering and early adjustment of grievances. This plan has since been put into operation by the Standard Oil Company of New Jersey in all of its plants in various states and by the Consolidated Coal Company, one of the leading anthracite producers, and several other smaller companies in anthracite fields.

The outstanding features of this Rockefeller plan are the employes' representatives and their conferences and their committees.

By secret ballot representatives are chosen annually by the employes from their fellowworkers in each mining camp and each division of the steel mills, one for every 150 employes, but never less than two in any camp or division.

The representatives, together with an equal number of the officers of the company, hold conferences at least three times during the year in the several coal mining districts, and similar conferences are held in the steel plant.

There is also an annual conference of representatives and officers of the company. Such a conference occurs with the employes of the mines as well as with the employes of the steel plant.

In addition there are in each district of the mining camps and in all of the divisions of the steel plant, four standing committes, each committee composed of three employes, selected by the representatives but not necessarily representatives themselves, and three officers of the company. These committees can initiate business as well as consider such matters as are referred to them.

The committees are: Committee on Co-operation and Conciliation; on Health and Housing; on Recreation and Education.

There is also an officer, known as the President's Industrial Representative, whose duty it is to visit currently all the mines and confer with the representatives. A similar officer performs a like function in the steel plant. These officers are also available for conference at any time at the request of the representatives.

This plan is further supported by the employes' right of appeal in the case of any grievance, real or imaginary. Whether it is fully so or not, it is the fashion at the present time to attribute most of the internal troubles of an industry to the subordinate officers such as shift bosses, foremen, and superintendents. The right of appeal being recognized, if an employe does not get satisfaction from his immediate superior, he has, without prejudice to himself or his position, the right to take his grievance higher up, and the machinery is provided for handling this case to that point where the grievance is completely satisfied. Another outstanding feature in support to this plan is the so-called "Employes' Bill of Rights." This covers such matters as the right to caution and suspension before discharge, except for such serious offenses as are posted at each mine; the right to hold meetings at appropriate places, outside of working hours; and the right without discrimination to membership or non-membership in any society or organization.

As the result of the operation of this plan there has resulted uninterrupted operation of the plants together with increased output; improved living and working conditions; frequent and close contact between employes and officers; elimination of grievances as a disturbing factor; good-will developed to a high degree; and the creation of a community spirit which has been fostered in many ways.

This plan was adopted by the unanimous vote of the board of directors and by the affirmative vote of 78 per cent of the employes.

The Leitch Plan.—Perhaps that development of industrial technical representation for the employes which has reached its highest development in this country is that known as the Leitch plan, originated by John Leitch of Philadelphia. This plan is applied to any one plant or group of plants under the same management, and consists in a three-chambered body operating along parliamentary lines and based on our own government. This plan has been developed through an experience of 10 years and many and varied industries. Because it is modeled on our constitutional government it has been called by its originator "Industrial Democracy." In a large organization there are three bodies to accomplish this work called a house of representatives, a senate and a cabinet. The house of representatives, so-called, is composed of employes elected by fellow-workers on the basis of the number of people employed in each department. The advantage of this is to give every phase of the business a proportionate voice in the consideration of the problem. The senate is made up of the under-executives, department heads, foremen, etc., according to the size of the establishment, the idea being that its membership shall comprise all of those under the grade of chief executive officers. The meetings of both these bodies, the senate and the house, are weekly and are always held on company time, which seems to be an absolute necessity in order to get attendance. To do otherwise has meant failure wherever the plan was tried. Every dispute, whether between workmen, a workman and a foreman or an excutive, between foremen, or between a foreman and an executive, may come before the senate or the house. Usually a committee is appointed to investigate the affair and report its findings back to its parent body. Then a shop law is passed covering or correcting the point at issue. The bill has to be passed by both the house and senate and then be approved by the cabinet. The cabinet consists of all of the executive officers of the company.

Wonderful results have been obtained wherever this plan has been adopted. Wages have been increased and rates of production have been increased and production cost has been decreased. This very striking combination of desiderata is accomplished by what in my opinion is the crux of the whole matter: Any savings due to any decreased waste or increased efficiency are divided "fifty-fifty" between the men and the company, and that portion going to the men is given in the form of a dividend and is declared on a monthly basis. Experience has shown that, since inattention, tardiness, irregularity, and inefficiency tend to reduce their profits, all men very quickly, after once convinced of the sincerity of the management in this scheme of co-operation, eliminate them because it is for their personal profit.

This scheme has all of the financial advantages of profit-sharing and stock-ownership, with the additional advantage of individual incentive. In profit-sharing and stock-ownership the return to the employe is dependent solely on the executive who is running the business and the system of bookkeeping and the employe gets about what the director decides he shall have. With this scheme of industrial representation, the employe gets a fixed ratio of what his individual genius and efforts made for the company based on past standards. This inculcates not only industry but inventive application, and there are many instances of wonderful developments of labor-saving machinery as a direct result.

An Ohio Steel Fabricating plant paid riveters $37.08 and $28.03 per hour in April 1917, and the records for the assembly room then stood at 15,017 rivets; exactly four months later, under this industrial scheme, they were paying $47.02 and $35.04 respectively to the same classes of men, but the average of rivets had risen to 18,967.

Representation Plan of Youngstown Sheet & Tube Co.—The Youngstown Sheet & Tube Co., after a careful study of the three years successful operation of the Rockefeller plan as incorporated at the Colorado Fuel & Iron Co., offered its employes the opportunity to adopt some such method. The proposition was enthusiastically approved. A plan was developed to suit their particular problem which resembled more the Bethlehem Steel plan than the Rockefeller plan, and it has been working equally well.

The procedure for adjustment of difficulties in this plan is as follows:

Any matter which in the opinion of any employe requires adjustment and which such employe has been unable to adjust with the foreman of the work on which he is engaged, and any matter deemed proper to be submitted by any committee, may in the case of such employe, be taken up, either in person or through any representative of his division, or in the case of a committee, may be taken up by the committee with the following named persons and in the order named:

First—The superintendent of the department to which the division belongs.

Second—The management's representative.

Third—The superior operating officers of the company, who shall endeavor to effect a settlement, or who may with the approval of the employe, or representative or committee submitting the proposition, refer the same to any joint committee.

Where a satisfactory disposition of any such matter has not been effected within a reasonable time, the employe through his representative, or the committee, or the managemnt, through the management's representative, may require such matter to be referred to the joint general committee on appeals, by a request in writing addressed to said committee, specifying in detail the matter requiring adjustment and the reasons which warrant its consideration by said committee.

The joint general committee on appeals shall consider any such matter with reasonable promptness at a regular or special meeting, and may adopt such means as are necessary to ascertain the facts and effect a settlement.

If the joint general committee on appeals fails to effect a satisfactory settlement, the matter shall be referred to the president of the company. If the president of the company and a majority of the employes' representatives on the joint general committee on appeals fail to effect a satisfactory settlement, they shall refer the matter to arbitration as they may determine at the time, according to the nature of the controversy.

If the president and a majority of the employes' representatives on the joint general committee on appeals are unable to agree upon an arbitrator, or arbitrators, the president shall select one arbitrator and the employes' representatives on the joint general committee on appeals shall select one arbitrator, and the two arbitrators thus selected shall endeavor to settle the matter in dispute.

If the two arbitrators are unable to settle the matter in dispute, they shall select a third arbitrator. If they cannot agree upon a third arbitrator, the third arbitrator shall be selected by the presiding judge of the district court of the United States for the Northern District of Ohio, Eastern Division; and the decision of any two of the three arbitrators thus chosen shall be final and binding on both parties.

Management of Municipal Water and Light Plants*

By J. C. MANNING
City Manager, Hays, Kans.

An Indictment of Municipal Ownership.—Mr. Emerson McMillan. Chairman of the Board of the American Light & Traction Co., in his address on public ownership of public utilities before the National Civic Federation in New York on Sept. 11th, made this statement: Municipal ownership of public utilities is unsuccessful at the present time, and will remain so as long as the present form of city government exists; plants under private ownership are not only more efficient, but give a better service at a lower cost to the public.

Mr. McMillan stated that the cost of municipally owned utilities is usually higher when all the legitimate items of expense are given consideration; and that the equipment installed in a municipally owned plant is usually too poor for efficient service or is badly adjusted to the operating demands, which condition results from a lack of business methods and lack of organization.

The sad part of the whole matter is that in many cases of municipal ownership the facts are just as Mr. McMillan has stated; but the reasons for such bad conditions are easily explained and there is no justification for the failure of municipal plants to equal and even exceed the standards set by the best privately owned and operated plants.

The failure of municipal plants is caused first, by the employment of inefficient help and second, by political interference.

Municipal Plants Lack Cost Data.—Very few municipally owned light plants know whether they are running on a paying basis or not. Especially is this true of the smaller cities and villages, as very few of them know the value of their light plant, what the total output is, what they have spent for repairs, reconstruction, plant additions, or overhead. This information can only be brought about by the installation of proper instruments and meters and by the introduction of proper time cards and cost finding methods.

A great many cities who employ a manager or superintendent for their light and water plant, pay him a good salary and then handicap him by curtailing his authority and expenditures. The average man in civil life may not readily see the advisability of spending $300 to $500 for meters and instruments that he personally cannot see the use of.

Knowledge of Cost Elements Essential.—In cases where I have been called upon to analyze the conditions of municipal plants, I have found them making a special rate for some industry or firm without the faintest knowledge of what the cost of the production of the current was. No one who is a successful retail merchant would undertake to sell his goods without knowing the cost of the commodity. Think of a successful baker selling bread without knowing what his flour, yeast, potatoes, salt, sugar, shortening and labor cost him. Still, when he gets on the city council he will permit the sale of electric energy without knowing the unit cost per kilowatt hour of coal, water, boiler compound, labor, interest, depreciation and overhead. Few of the average councilmen know that the cost of production is greater at certain hours of the day than others. In many cases the unit working is not an economical one for the load they are carrying. For instance, I recently visited a plant where they were firing two 150 H. P. boilers for a 35 kw-hr. load or about one-fourth load for each boiler. When I asked the foreman why he was running two boilers, he replied, "so as to have plenty of steam when the load comes on."

Now, if that plant had installed indicating watthour meters and kept a log sheet recording the load every hour, the fireman would have known at just what hour in the day his peak load would come on and he could have carried a bank fire in one boiler until about an hour previous to the time this load would come on. This log sheet would show the manager of this plant which fireman was producing the best results and entitled to the highest wages.

In other instances I have found cities furnishing electricity for pumping water where they have been very careful to meter the current used, but paid no attention whatever to how much water they were pumping. Consequently they had no way of knowing the cost per 1,000 gal. In other cases the light and water plants were in the same building, the same boilers furnishing steam for both plants without any way of determining the distribution of the steam between light and water.

Political Interference Greatest Handicap.—The greatest cause of failure of municipally owned utilities is political interference. In privately owned plants the directors employ a manager and put him in charge of a plant with full authority. When he comes in with a requisition for material or equipment and can show the directors that it is necessary for economical operation or that it is a good investment, the material is purchased; if the privately employed manager discharges an engineer or some other employee for incompetency, he is upheld in his act. While in most cases of municipally owned plants the manager or superintendent must go before the city council and tell his troubles. The council leaves the purchasing of the equipment to some one who knows nothing at all about the working conditions or the quality of the article in question, but who will purchase the equipment wherever it can be purchased the cheapest, without the least regard for quality or adaptability. And when a municipal plant superintendent discharges someone, he stirs up a political hornet's nest.

Conditions Necessary for Successful Operation.—Municipally owned light plants can be run successfully in any city under proper conditions. It must have a manager or superintendent capable of running it and that man should have full charge. I do not mean by this that he should be turned loose with no one to check him, but he should be chosen only after careful consideration of his ability, personality and habits; after being chosen he should be allowed to demonstrate his ability and if he is not successful he should be removed. He should be under the supervision of the board of public works or of the light and water committee, as the case may be. His authority should extend to all branches of city service in which his department is effective. For instance, if it be a municipally owned light and water plant, he should be in full charge of office, plant, lines, public watering places, sewers, etc. All purchases should be made on requisition and as far as possible should follow the requisition to the letter.

In operation there should be no difference between municipally and privately owned utilities. There should be complete valuation of all utility property, and complete records kept at the power plant. All coal, ash and water should be weighed; fuel oil metered; feed water temperature recorded; and log sheets should be kept showing all this, also indicating watt hour load at all hours. All current should be metered, including street lights, at the switchboard; all service should be metered; meter records should be carefully kept in the field book and in the ledger; in addition to this, a card index of each meter showing manufacturing number, city number, and a complete history of the meter showing dates of test, repair and change of location.

All time cards should show careful distribution of time; separating repairs, reconstruction, inside wiring and attention to service and assistance to other departments. Stock room sheets should be kept, showing material used on each job, which will be the check against perpetual inventory sheets. Carbon copies should be made of all work orders, and a work order should be made for each job, no matter how small.

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*Abstract of a paper presented at the last annual convention of the League of Kansas Municipalities.

Courtesy and service should be the watchword and the meter man should be one of the most carefully selected of the entire organization as he comes in contact with the customers more than any one else. Personally, I am a firm believer in the Statler idea—"the customer is right"—and I find it a great deal easier upon listening to complaints to say that maybe we are in error than to say that we are right and afterwards have to apologize.

In conclusion I want to say the last and greatest duty of a manager is to see that all bills are collected on date of maturity. It is a strange thing to me that so many plants have such large outstanding accounts when all they need to force collection is a screwdriver. But I find in a great many municipal plants they are afraid to use it; or the managers are not backed by the city officials when they do force collections

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The Engineer and the Bond Campaign for Municipal Improvements*

By ROBERT E. McDONNELL,

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Most engineers' reports are really prepared with the ultimate object in view of a bond issue for the improvements, yet to read one through, one would think they were written to impress the laymen with the technical training of the author. The engineers who prepare fine, readable reports are only doing a small part of their work, the real value of an engineer's service to the public comes in presenting his subject so clearly to the voters that every one will see it, understand it, talk it and vote for it.

The average engineer's report on improvements is too long, dry and technical and frequently leaves the officials in the air as to what to do next. The real job of raising the funds is as much the engineer's obligation as showing how much is needed.

Many worthy projects are never brought to a vote and many equally worthy ones are voted down merely because the engineer failed to properly illustrate the various features. In your own experience, how many times have you, as an official, known to your own satisfaction the need of a bond issue for water, light or sewer improvements, yet you hesitate merely because the public does not possess the same knowledge as you possess regarding the improvement? You cannot go out and individually talk and convince every one of your friends of the need of the improvement, but the illustrated bond campaign does this for you. Only recently a conference with some Iowa city officials disclosed a polluted water supply and an inefficient lighting plant. The mayor remarked: "We know the needs of the plants and have voted at it, but met defeat three times." The defeat of worthy projects is invariably due to two causes—poorly presented and not understood or lack of confidence in the administration. In the Iowa case it was poorly presented but, following a three weeks' campaign, wherein every phase of the project was illustrated, the improvements were almost unanimously authorized.

The Illustrated Bond Campaign.—Pictures are plainer than print—they present pertinent points only. They are in the language the people know and understand. Photographs of inefficient machinery and its cost of operation are shown by stereopticon slides, followed by one showing efficient equipment and the saving in operation costs. Alleys showing outhouses, garbage piles, ash heaps, etc., make good illustrations of the lack of sewers and sanitation and contrast this with stereopticon slides showing abandonment of alleys with the installation of sewers, with its beautiful back-yard flower beds and creek banks beautified.

Health statistics graphically shown on a slide of your own city, even showing poor results and you are ashamed of them, serve to stimulate an interest in bettering the conditions. Slides showing the typhoid rates of other cities with pure water supplies emphasize the need of action in your own city. Typhoid and many other waterborne disease are preventable diseases, preventable by proper precaution in water supply, food and sanitation.

The time is fact coming when the sheriff and police officers will investigate and fix the responsibility for every case of preventable disease. Doctor Hazen, an authority, says for every case of typhoid someone ought to be hanged. The real town booster gains nothing by covering up and minimizing the town's sore, festering and ugly spots, but let them be known and the town will soon have none of these to apologize for.

Portrayal of Facts by Slides and Moving Pictures.—Proper publicity and presenting of engineering reports needs no exaggeration to make the argument effective, but a real portrayal of plain facts by slides and moving pictures merely brings to the attention the need of improvements, and where the necessity is shown, the cash is always forthcoming.

During a campaign for sewers and a modern sewage disposal plant, recently, the writer found the moving picture shows all anxious and willing to show such films as "The Daily Life of a Fly"; also, the public meetings were packed to see the plans and estimates shown on the screen, illustrating the proposed improvements, together with pictures showing the best examples of similar improvements in other cities.

There is no municipal improvement that cannot be graphically illustrated by pictures and diagrams and they are plainer than printing or typewriting. Maps showing water or sewer lines, with their sizes and locations, can be shown by slide. White-way or ornamental lighting can be well illustrated. The writer has conducted successful campaigns for bonds by this method, covering such a variety of subjects as the following: Campaigns for municipal ownership of water works and lighting, for sewers and sewage disposal plants—new water supplies, filtration systems, water power, park and street improvements.

Public Sentiment and the Improvement.—It is an unfortunate fact that many a needed public improvement is delayed to the point of criminal negligence on the part of those in authority, solely on account of their fear that public sentiment may be against the improvement.

The superintendent of the city water works may know that the water supply is inadequate or that the pumping machinery is insufficient to give fire protection, and he may confide this alarming situation to the other city officials, only to be told to keep the matter hushed up, as they do not dare ask the people to vote bonds until after the spring election, and they will try to pinch along another season on their present equipment. They are willing to gamble against Fate. They take a chance, and sometimes they lose, rather the public loses property worth many times what the waterworks improvements would have cost; and that is not all—the public then awakens to the necessity and rebuilds its water plant—and if justice falls where due, the public also selects new city officials. But this illustration pertains only to property loss—material things. I have in mind a far worse negligence—criminal, without a doubt, but wholly due to the fear of taking the public into the confidence of those responsible for public property. This is a case where a city is supplied with pure water, but the plant facilities are not adequate to meet the requirements of the dry season, and as a consequence of this condition of affairs it becomes necessary to introduce polluted water into the city mains at times during the hot summer season. The superintendent of this waterworks system told me he was simply "up against it" and he did not dare mention the true situation publicly for fear of the storm of indignation that would fall upon him. And yet this city failed to vote bonds for an increased pure water supply when the question was submitted to a vote. The reason it failed was plainly due to the fact that the city officials did not have any definite plan prepared to show how they proposed to use the money, nor did they make any organized campaign to educate the public to the necessity of the improvement.

Engineer's Report Should Precede Bond Election.—Many municipalities make the mistake of proceeding with a bond issue without first having an experienced engineer's report covering cost, comparison of various features and recommendation about the project, with the result that when voters are asked for bonds, the questions the voters ask about the project cannot be intelligently answered and the officials are put in a defensive position and the voters are groping in the dark as to some phases of the question. Then again, the cost, or amount of bonds, will be questioned unless it is based on a very carefully made plan and estimate.

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*From a paper presented at the last annual meeting of the Kansas League of Municipalities.

A wrong impression or conception of a project often defeats it. The voters have a right to know and should know every detail of the project before voting.

The correct cost and proper explanation of the project, or the first impression of it, is the lasting one, and this should be given at the outset and not after there are hundreds of half-baked opinions spread broadcast regarding the projects An engineer's greatest value to the community comes in by properly conceiving the character and extent of the work before a bond election and, like the skilled diagnostician in studying the symptoms, the causes, etc., he can prescribe correct treatment before mistakes are made. Cities often fail to realize that it costs no more for an engineer's services right at the outset than it does to call him in after funds are provided.

An improvement that may apparently seem dry and uninteresting can in this way be made such a live, interesting subject that civic organizations, women's clubs, labor unions, etc., are seeking an illustrated talk before their organizations, which not only instructs, but entertains. How many people nowadays would go to hear a paper read or a lecture, even if ably presented? The public likes to see as well as hear, and to see by slides what their neighboring cities are doing helps to do better our own problems.

This method, of course, involves much added work for the engineer, but it is worth while, at least in the satisfaction that comes from a consciousness of a public duty discharged to the best of one's ability. A study of this subject has led us to adopt the graphical method of presenting everything that can be pictured. The results have been gratifying and show that in the last two years 30 projects have been handled in this manner without a single bond defeat, although ten of the projects had previously met defeat before the illustrated bond campaign had been applied. However, the greatest result of all comes in the fact of a better citizenship, a lessening of the general and typhoid death rate through better water supplies or sewerage, an awakened civic pride and increased trade flowing to the cities that have made their public improvements models in efficiency and service to the public.

Experience with Activated Sludge Process at Manchester, England

In the last annual report of the Manchester, England, River Department, extensive reference is made to the activated sludge plant at the Withington works.

The following data from this report gives some results obtained at this plant, information concerning a "fill and draw" plant at Davyhulme, and a description of a new large scale continuous-flow plant under construction.

It should be noted that in the notes that follow that all quantities are in "Imperial" gallons.

During the year a total volume of 59,288,000 gal. of sewage, which had been screened and passed through detritus tanks whose capacity is equal to approximately 40 minutes' dry-weather flow, was treated in this plant, an average of 172,000 gal. per day (actually in operation).

The plant was out of commission for a period of 20 days in consequence of the closing down of the power plant. The operation of the plant has been handicapped by an uncertain air supply consequent on difficulties experienced, especially during the summer months, in maintaining an adequate steam supply. The actual volume of sewage purified by this plant has, of course, been influenced materially by this factor and also by reason of its use as a demonstration plant for the purpose of obtaining additional information with respect to the factors controlling its economic operation.

The following typical average analytical returns will give a general idea of the results obtained:

AVERAGE RESULTS IN PARTS PER MILLION.

Dry Weather Sewage—Low Air Supply.

Flow roughly proportional to rate the sewage is received.	Screened and detritus-freed sewage.	Effluent.
Four hours' oxygen absorption	39.0	7.3
Free and saline ammonia	26.5	23.2
Albuminoid ammonia	6.6	1.14
Nitrite and nitrate (in terms of NH_3)	....	1.43
Dissolved oxygen absorption (*Royal Commission Test)	....	9.29
Volume of sewage treated	250,000 gal. per day.	
Air consumption	1.0 cu. ft. free air per gal. of sewage treated.	

Dry Weather Sewage—Maximum Air Supply.

Uniform rate of flow.	Screened and detritus-freed sewage.	Effluent.
Four hours' oxygen absorption	33.3	6.6
Free and saline ammonia	30.0	15.44
Albuminoid ammonia	5.86	1.00
Nitrite and nitrate (in terms of NH_3)	.....	6.43
Dissolved oxygen absorption (*Royal Commission Test)	.....	9.29
Suspended solids	180.2	30.0
Volume of sewage treated	250,000 gal. per day.	
Air consumption	1.7 cu. ft. air per gal. of sewage treated.	

Wet Weather Sewage—Low Air Supply.

Uniform rate of flow.	Screened and detritus-freed sewage.	Effluent.
Four hours' oxygen absorption	25.3	6.7
Free and saline ammonia	19.4	16.3
Albuminoid ammonia	4.58	1.73
Nitrite and nitrate (in terms of NH_3)	.....	3.72
Dissolved oxygen absorption (*Royal Commission Test)	.....	10.0
Suspended solids	130.1	60.1
Volume of sewage treated	344,000 gal. per day.	
Air consumption	0.80 cu. ft. free air per gal. of sewage treated.	

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*Standard recommended = 20.0.

Summary of Experiences from Last Year Operations.—The experience gained with this installation during the year under observation may be summarized as follows:

The satisfactory results previously published obtained by the treatment of the Withington sewage by the activated sludge process have been well maintained.

The idea that the scientific control required for the successful operation of the process would render its adoption impracticable has been proved to be without foundation. Provided care is taken to establish the factors controlling success—i.e., the period of aëration and volume of air required for the production of a satisfactory effluent from any given sewage—no difficulty need arise in the operation of an activated sludge plant if proper attention is paid to the efficient settlement of the sludge and to its regular return to the aëration chamber, so as to maintain the requisite volume of sludge in contact with the sewage.

This volume may vary considerably—e.g., from 15 per cent to 30 per cent—by volume measured after one hour's settlement, without interfering materially with the purification effect. Unless a high degree of nitrification is desired, the operation of the plant is facilitated by employing a sludge content approaching the lower of these two limits. In this way there is less liability of difficulty with sludge settlement, and, of course, the volume of sludge in circulation—i.e., to be raised by air lift—is reduced, while it is quite sufficient to produce a perfectly clarified and thoroughly stable effluent.

One of the outstanding features of the experience with this plant is the highly satisfactory operation of the diffusers employed. It has not been necessary to replace any of these diffusers, although at the time of writing they have been in actual operation for a period of two years. Only six of the 300 employed have been removed from the tank, and replaced after cleaning, to remedy indifferent diffusion. It is also important to note that, so far, no signs of clogging have been observed. Careful observations of the air pressure employed give no indications of any rise due to increased friction. The air pressure only varies from 3.1 lb. to 3.25 lb., dependent on the volume of air passed through the diffusers. In this connection it will be remembered that the depth of water in the aëration tank is 6 ft., measured from diffuser to water level.

The earlier determinations of the column of air required have been confirmed. Unless a high degree of nitrification is required, an air consumption of 1.0 cu. ft. of free air compressed to 3.1 lb. per gallon of sewage treated is sufficient to produce a satisfactory effluent under average conditions. In periods of dry weather this volume should be increased to a minimum of 1.25 cu. ft., mainly to avoid disturbance with the settlement of the sludge. It would appear that the additional air supply is concerned with the maintenance of a thoroughly active state of the sludge, and it is possible that re-aëration of the sludge prior to its return to the aëration chamber might be advantageous, even with a weak sewage of the character of that treated at the Withington works. In wet weather, when the sewage is diluted by rain, satisfactory effluents may be maintained with an air consumption as low as 0.8 cu. ft. free air (compressed to 3.1 lb.) per gallon of sewage treated.

In view of the criticism directed against the employment of a more or less uniform rate of flow throughout the 24 hours, comparative trials have been made with the rate of flow, roughly proportional to the rate it is received at the works—i.e., with the daily flow approximately double the night flow. The results obtained show that the purification is well maintained, although the composition of the final effluent varies slightly on account of the fact that the average strength of the sewage thus treated is increased.

Further determinations of the sludge production agree fairly closely with the figure already published of 0.5 ton dry matter per 1,000,000 gal. of sewage treated. The actual volume of sludge this solid matter represents depends on the means adopted for the removal of the surplus sludge from the installation. The water content of the sludge removed need not exceed 98.8 per cent, which means an actual sludge production of approximately 42 tons per 1,000,000 gal. sewage treated. As previously reported, the volume of this sludge can be considerably reduced by ordinary settlement.

Dewatering Experiences.—The problem of dewatering the resultant sludge so that full advantage may be taken of its value as a fertilizer has received attention, but the progress made in this direction is not such as could be desired.

Fairly extensive trials have been made with an experimental continuously-operated centrifuge. The sludge has been treated by this machine, both with and without preliminary treatment, such treatment having included (1) settlement; (2) acidification; (3) application of heat.

The results so far obtained are not very encouraging, the best trial under most favorable circumstances yielding a product containing 85 per cent water. While this means a very great reduction in the volume of the sludge treated, the water content is still too high to consider direct heat as a means of reducing the material to a marketable product.

The "fill and draw" activated sludge plant at Davyhulme has been in operation throughout the year. Generally speaking, this tank, whose capacity is 20,000 gal., has received three fillings per day, with an average aëration period of five hours, and has thus dealt with 45,000 gal. of screened sewerage per day.

The following average analytical returns show that a satisfactory effluent has been obtained:

RESULTS IN PARTS PER MILLION.

	Screened sewage.	Effluent.
Four hours' oxygen absorption	95.0	13.1
Percentage purification	....	86%
Free and saline ammonia	27.7	13.1
Albuminoid ammonia	7.7	1.28
Percentage purification	....	85%
Nitrite and nitrate (in terms of NH_3)....	....	6.2
Dissolved oxygen absorption	....	8.3
(*Royal Commission Test)		

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*Standard recommended = 20.0.

It has been kept in operation mainly to note the results to be obtained, over long periods, in the treatment of the city sewage, containing as it does a great variety of trade wastes.

New Large Scale Continuous-Flow Unit. It is satisfactory to report that there has been no material interference, due to the presence in the sewage of inhibitory trade waste, during the year under observation. As previously reported, however, the trouble has been experienced occasionally by the admittance to the tank of an undue proportion of oily matter, which, although it has not interfered with the bacterial activity of the sludge, has, by emulsification, resulted in the production of turbid effluents. Such experience confirms the opinion, frequently expressed, that arrangements should be made whereby any appreciable amount of oils, etc., are removed from the sewage prior to treatment in the aëration chamber. This has been borne in mind in the design of the large scale continuous-flow unit described below.

This plant has been under construction during the year. Its design is based on the experience gained with the operation of the plants at the Withington works and elsewhere, and also on the information obtained from a glass demonstration tank constructed by Messrs. Jones & Attwood, Ltd., at their works to study the currents produced by the admission of diffused air into water.

Briefly, the plant may be described as follows:

Preliminary Grit Chambers.—These detritus chambers are provided owing to the inadequacy in times of heavy rainfall of the existing screening and detritus chamber at the entrance to the works. The dimensions of each of these two chambers are 12 ft. 8 in. by 15 ft. by 8 ft. 6 in. deep (approximate water level), and their combined capacity is 20,000 gal. Two Clifford inlets are arranged in each tank, and the sewage is raised by air lifts (combined capacity 2,000,000 gal. per day) from these preliminary grit chambers to the aëration chamber. These chambers should also act as grease traps and arrest any undue proportion of oily matter in the sewage.

Aëration Chamber.—The aëration chamber, which is 241 ft. long and 9 ft. deep (water level to diffuser), is divided by two longitudinal walls so as to form a channel 8 ft. wide and 723 ft. in length. Its capacity is 322,425 gal. The floor of the tank is level throughout. Aëration is effected through lines of diffusers placed alongside the curved footings of the divisional walls on one side of the channel only. The diffusers are each 4 ft. by 7 in. (over all), so that their total area is approximately one-fourteenth of the aëration tank area. The ratio of actual diffusion area to total tank area is approximately 1:18. An overhead system of air pipes is provided, and the air admitted to the diffusers by a series of down-pipes, one to each diffuser. Valves are arranged on the air mains so that the tank may be sectionized so far as air supply is concerned. In addition, each down-pipe is fitted with a needle and orifice control for securing uniform air distribution. Cross-baffle walls, each with 3-ft. by 1-ft. openings over the diffuser line, are constructed at intervals of 16 ft. along the whole length of the aëration channel.

Sludge Re-aëration Channel.—This channel runs alongside the aëration chamber, and is consequently 121 ft. long. It is 4 ft. 6 in. wide, and its capacity is 52,650 gallons. The re-aëration of the sludge as it passes down this channel from the settlement tanks to meet the incoming sewage passing into the aëration chamber is effected through diffusers arranged similarly to those in the aëration tank. Cross-baffle walls are also provided. Surplus sludge will be removed from the end of this channel adjacent to the grit chamber through a pipe which passes to the existing sludge subway.

Settlement Tanks.—Two types of settlement tanks are provided, which can be operated independently or together in parallel:

(a) Circular Tank.—The diameter of this tank is 29 ft. 2 in., and its mean depth to water level is 11 ft. 6 in., with a water-holding capacity of 56,130 gal. Four Clifford inlets arranged symmetrically are provided and the effluent leaves over the periphery cill. A helical scraper operated through gear from a water wheel fixed in the discharge effluent channel is provided to move the deposited sludge to an opening in the center of the floor of the tank which communicates with a separate sludge pit. An air lift is fixed in this sump, by means of which the sludge is discharged into the sludge re-aëration channel.

(b) Inverted Pyramidal Tank, with four pockets.—This tank is 28 ft. 8 in. square; its depth from water level to the apex of the pyramids is 21 ft. 6 in. Its water-holding capacity is 69,370 gal. Four Clifford inlets are arranged over the center of each of the pyramidal pockets, and the effluent leaves the tank over a periphery cill. Earthenware pipes convey the deposited sludge to four separate sludge pits, each provided with air lift for discharging the sludge into the re-ëration channel.

The effluent from the plant passes through a measurement chamber prior to its discharge to the culvert entering the canal. It is anticipated that this plant will be capable of treating 1,000,000 gal. of the city sewage per day, with the production of a satisfactory effluent. At this rate the sewage would receive approximately six hours' aëration, and the sludge prior to its return to the aëration chamber would be re-aërated for from two to four hours, dependent on the volume of sludge in circulation.

While the general lay-out of this plant is somewhat similar to that of the installation at the Withington works, it differs in many respects from the latter plant in actual design. Such alterations in design have been adopted with the idea mainly of reducing the cost of construction without lowering the efficiency of the plant. The chief new features are the flat-bottomed aëration chamber, which does away with the costly concrete ridges employed in the Withington plant, and a reduction to the extent of 50 per cent of the diffusion area, with consequent considerable saving in the equipment charges. In addition, arrangements are provided for the re-aëration of the sludge in circulation, which it is considered will be advantageous in the case of the treatment of a strong trade sewage. The success or otherwise of this new design of aëration chamber will depend very largely on the volume of air required to produce a floor velocity sufficient to obviate the deposition of the sludge.

At the time of signing this report the construction and equipment of this plant is practically complete, but unfortunately it cannot be brought into actual operation until an auxiliary power supply is available. This matter has been subject to unavoidable delay, but a scheme is now in hand whereby electrical power will be obtained from the nearest public supply. The air necessary for the operation of the plant will be obtained from three electrically-driven Reavell air compressors, the capacity of each of which is 500 cu. ft. per minute.

The estimated cost of this installation was $65,000, made up as follows: Construction work, $45,000; equipment, $15,500; erection and housing air equipment, $4,500.

The total expenditures during the period covered by the report was $26,795.

Regulations of North Dakota State Board of Health for Sewer Grades

The North Dakota State Board of Health has just issued new regulations governing water, sewerage and refuse disposal. No system of water supply, sewerage or refuse disposal to serve more than 25 persons in the state shall be installed until complete plans and specifications have been approved by the Board.

For sewers, minimum grades which will produce a theoretical velocity of 2 ft. a second are required, and are as follows:

Size of pipe	Fall in feet per 100 ft. of sewer.
8 in.	0.40
10 in.	0.29
12 in.	0.22
15 in.	0.16
18 in.	0.12
20 in.	0.10
24 in.	0.08

The sewers should have a capacity when flowing half full sufficient to carry twice the future average flow 25 years hence, plus a sufficient allowance for ground water infiltration.

Under the rules governing the design of sewage treatment plants, it is stated that no by-passes which may allow raw or partly purified sewage to be discharged from the sewers or disposal works shall be included in the plans, except by special permission of the board.

The rules cover most of the essential features in the design of both water and sewerage treatment plants, dwelling to some extent upon the details to be shown on the drawings.

Annual Meeting of Associated Manufacturers of Water Purifying Equipment

The annual meeting of the Associated Manufacturers of Water Purifying Equipment was held at the Bellevue Stratford Hotel in Philadelphia, on Feb. 4, 1920. Practically the entire membership was represented at a meeting of unusual progress and interest. Born out of war-time necessity to assist in speedy production of water purifying equipment, the association now continues with the object of assisting in every way the water purification industry as a whole. Much has been accomplished in the past year in that standard sizes for pressure filters have been agreed upon and much progress has been made by the committees on standards in making preliminary report on sizes and strength of materials entering into filter construction. The committee is also working on the standardization of contracts. It is anticipated that during the coming year, an acceptable standard contract form will be prepared for use by the associated manufacturers. Mr. Arthur M. Crane representing the New York Continental Jewell Filtration Co. was elected chairman for the year 1920, succeeding F. B. Leopold of the Pittsburgh Filter Co., who was elected to the executive committee to fill the vacancy created by the election of A. S. Garrett of the American Water Softener Co. to the position of vice-chairman succeeding Mr. Crane. Mr. H. T. Tate of the Borromite Co. of America, remains secretary and treasurer. Membership in the association is open to all firms, companies and individuals regularly engaged in the manufacture of water purification equipment whether for filtration, softening or sterilization.

City Planning Board for St. Paul, Minn.

George H. Herrold, Office Engineer, Department of Public Works, St. Paul, Minnesota, has been appointed managing director and engineer of the St. Paul City Planning Board. This is a newly created position brought about by ordinances providing for a city planning board, to study the physical conditions of this city and prepare a comprehensive plan for its future development. The board also will have jurisdiction in all matters concerning or relating to the platting of new areas or replatting of existing areas; the vacation or rearrangement of boulevards, streets or alleys; the routing or rerouting of street cars and other means of transportation; the assignment of traffic to particular arteries of travel; the location and development of parks, playgrounds, parkways or other public places; the location and design of all public buildings, bridges, monuments and street fixtures; the establishment of building lines; the establishment of restricted building districts; and all other matters relating to the planning or replanning of the city shall be referred to the city planning board for its consideration and recommendation at such times as the council may direct before final action is taken thereon by the council.

The city planning board of St. Paul has been in existence about a year and has, during that time, created a public sentiment which has resulted in its securing an appropriation of $50,000 to be expended during the next two years for surveys and a plan.

Personals

Clyde Fulton has been appointed city manager of Roswell, N. Mex.

Ross J. Buck has been appointed city engineer of Muskegon, Mich.

George Sperbeck has been appointed assistant city engineer of Alameda, Calif.

J. W. Greer, for several years city manager of Bryan, Tex., has been appointed city manager of Tallahassee, Fla.

Joseph Firth, formerly city engineer of Charlotte, N. C., has been appointed city manager of West Palm Beach, Fla.

M. A. Turner, for the past two years city manager of Ranger, Tex., has resigned and will engage in business in that city.

John W. Ballew, for the past 4 years city manager of Hickory, N. C., has resigned and will engage in business in that city.

L. Herbert Kidd has resigned as city engineer of Knoxville, Tenn., and will become city manager of Kingsport, Tenn. F. L. Maloney succeeds Mr. Kidd as city engineer.

George O. With has resigned as city engineer of Joliet, Ill., and has accepted the managership of the Chicago office of the Consolidated Expanded Metal Co., of Braddock, Pa.

Wilbur Williams, for the past year borough engineer of Meyersdale, Pa., has formed a partnership with J. T. Monahan. Offices have been opened in the Hartley Block, Meyersdale.

Edwin P. Dewey, deputy city engineer of Pasadena, Calif., has been appointed city engineer, succeeding R. V. Orbison, who resigned recently to become city manager of South Pasadena.

J. T. Hurd has resigned as city engineer of Chippewa Falls, Wis., to accept a similar position at Eau Claire, Wis. He succeeds A. R. Garnock, who resigned recently to go into contracting.

L. N. Reeve has severed his connection with the A. I. S. C. as general supervisor of subcontracts and has become connected with Stone & Webster, 147 Milk St., Boston, Mass., as engineer in their hydraulic division.

Captain James N. Gladding, formerly city engineer of Albuquerque, N. Mex., and recently from military service overseas, has accepted the position of city manager of Albuquerque, vice A. R. Hehenstreit, resigned.

Industrial Notes

Myles B. Lambert, for many years actively connected with the work of the Westinghouse Electric & Manufacturing Co., was recently appointed manager of the railway department of the company.

Announcement has been made by the Westinghouse Electric & Manufacturing Co. of the appointment of W. S. Rugg, manager of the railway and marine departments, and Charles Robbins, assistant sales manager, as assistants to vice-president.

The Mathieson Alkali Works has established its headquarters at 25 W. 43rd St., New York City, and will sell all its products direct instead of, as heretofore, disposing of the greater part through Arnold, Hoffman & Co., Inc., Providence, R. I.

The American Steam Conveyor Corporation announces that arrangements have been made with the Wellman-Bibby Co., Ltd., 36 Kingsway, London, W. C. 2, England, to act as their representative in Great Britain and Ireland for the sale of the American steam ash conveyor.

Joseph H. Lecour, New York, has been elected treasurer of the Mitchell-Rand Manufacturing Co. of that city, manufacturer of structural paints, waterproofing compounds, etc. He succeeds W. E. G. Mitchell, who will devote his entire attention to his duties as vice-president in the future.

Railways and Excavation Monthly Issue

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Roads and Streets—1st Wednesday
(a) Roads
(b) Streets
(c) Street Cleaning
(d) Municipal Miscellanies
(e) Management and Office System

Waterworks and Hydraulics—2nd Wednesday
(a) Waterworks
(b) Sewers and Sanitation
(c) Irrigation and Drainage
(d) Power and Pumping
(e) Management and Office System

Railways and Excavation—3rd Wednesday
(a) Excavation
(b) Management and Office System
(c) Quarries and Pits
(d) Steam Railways, Construction and Maintenance
(e) Electric Railway Construction and Maintenance

Buildings and Structures—4th Wednesday
(a) Buildings
(b) Bridges
(c) Harbor Structures
(d) Miscellaneous Structures
(e) Properties of Materials
(f) Management and Office System

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Railway Regulation Is Entering Upon Its Final Trial

In a recent address Herbert Hoover said that government regulation of railways is about to be given another, and probably a final, trial. There was the implication that the success of this final trial rests entirely with the railways. Apparently Mr. Hoover has not acquainted himself with the reason why government regulation of railways has been unsatisfactory.

Thirteen years ago the Interstate Commerce Commission was given power to fix rates. About the same time many state commissions received similar powers. And the fun began.

Wages and prices were rising steadily, several per cent annually; taxes began to ascend even more rapidly, but railway rates were either cut or held down. Railway officials began to devote more time to reading commission and court decisions than to studying operating economics. For ten years the reading columns of railway periodicals have been largely filled with arguments and news about railway rates, rate decisions, public relations, and all that retinue of text that bowed itself upon the stage when King Rate Regulation entered.

Much has been learned from all this discussion, and probably it was inevitable that the knowledge should have cost a pretty penny. The cost is not measurable in the net income that railway owners lost. That was but a fraction of the total cost. The major cost of acquiring our knowledge about public regulation of railways has been the retarded development of our railway system.

Now that we have acquired this expensive knowledge, it behooves us to use it to avoid repeating the mistakes of the last ten years. What have been the principal mistakes?

First, the belief that rate regulating commissioners are fully qualified for their position if only they are honest.

Second, the belief that a commission should follow court precedent in point of slowness in rendering decisions.

Third, the belief that the sins of the original promoters of railways should be branded upon the hides of the present stockholders.

Fourth, the belief that railway officials are bluffing when they say that investors refuse to invest in a sure thing when the "sureness" is of no more than 6% net earnings if they guess well and nothing whatever if they guess ill.

Fifth, the belief that the public will applaud every rate reduction and condemn every rate raise.

Sixth, the belief that net earnings should be limited to a definite percentage on the investment.

Seventh, the belief that all who testify against the railways are unprejudiced while all who testify in favor of the railways are prejudiced.

28 Pages=40 pages

The 28 pages of articles in Engineering and Contracting contain as many words as 40 pages of the size and typography commonly used by other engineering periodicals. Ours is the same size of type and typepage as that of The Literary Digest—easily read, yet giving a large volume of reading matter per page. Our 28 pages of articles would fill 112 pages of the standard 6x9 in. text-book. It would take 10 such books of 580 pages each to hold all the articles printed each year in Engineering and Contracting, to say nothing of our weekly construction news.

Eighth, the belief that railway regulation is merely a step along the trail of evolution toward ultimate public ownership.

Too many railway commissioners have been socialistically inclined. Too many have had their eyes fixed upon prospective positions as state governors. Too many have lacked judicial temperament. Too many have taken their positions merely as fill-gaps or as stepping stones. No administration is better than the men who administer it; no court is more just than the judges who compose it. A rate regulating commission is partly administrative and partly judicial. It succeeds or fails in the performance of its duty in proportion as its members are honest, competent and courageous.

The Prospect of Lower Interest Rates and the Consequent Effect Upon Railway Construction

In another editorial article we have given certain reasons why the values of railway securities will rise greatly during the next few years. To the reasons there given another may be added, namely the probable decrease in interest rates.

It is one of the phenomena of rising commodity prices that interest rates also attain a higher level. One of the reasons for this is the effort made by lenders to discount the depreciation in the value of money that occurs when average commodity prices are rising. Thus, if average prices are rising 2 per cent annually, the man who lends $1000 for a year at 5 per cent really makes only 3 per cent interest at the end of the year, for the $1000 that is paid back to him has shrunk 2 per cent in purchasing power. Hence in order to retain the same purchasing power of his $1000, the lender should receive 7 per cent interest, of which 2 per cent would serve to discount the rising prices, while 5 per cent would be left as interest.

As a matter of fact most lenders are not astute enough to do what they should do when average prices are rising steadily. But, on the other hand, men in active charge of business affairs watch the trend of prices very closely, and when they see a steady rise that shows no sign of lessening, they lay in larger stocks of materials, supplies and goods. To do this they borrow money and since they compete with one another in borrowing, they bid up interest rates. The result is that when average prices are rising several per cent annually interest rates usually average one or more per cent above the rate that prevails when average prices are neither rising nor falling.

Statistics as to interest rates show that, in general, they average well above "normal" during periods of rising prices and below "normal" during periods of falling prices. For five years we have had very rapidly rising prices. This has forced the interest rate up, so that at present it averages 6 to 7 per cent on good railway and public utility bonds, whereas prior to the war it averaged 4.5 to 5.5 per cent.

An additional factor that is now operating to hold up interest rates is the income tax. This tax takes capital from the more thrifty and transfers it to the less thrifty. Hence there is a smaller volume of capital seeking investment, and therefore a brisker bidding for loans, with a consequent stiffening of interest rates.

Unless a considerable quantity of gold is shipped to America from Europe, average prices will not rise much higher than they are. They are likely to recede very slowly, even more slowly than during the 12-year period following our Civil War; but even if average prices remain stationary, interest rates will fall, for no longer will business men seek to "over stock" in order to profit by a rise in prices. In short, interest rates will speedily drop to normal, unless the effect of the high income tax is sufficient to offset the effect of stationary prices. There is prospect of another reduction in the income tax rates in 1921, and when the reduction occurs there will follow a decrease in interest rates.

Consideration of these controlling factors makes it probable that in 1921 America will return to prewar interest rates. Since the value of a bond is its annual interest divided by the prevailing rate of interest on well secured investments, it follows that a drop in interest rates will be followed by a rise in the market price of bonds. Since a rising market for securities always attracts capital, it follows that railway and other public utility companies will find it progressively easier to market their securities.

These facts, taken with those given in another editorial article in this issue, convince us that the turn of the tide in railway affairs is at last in sight.

The Imminent Increase in Railway Earnings and the Consequent Era of Railway Improvements

Eleven years ago we predicted that an appraisal of all the railways in America would disclose that their cost of reproduction would exceed the par value of their stocks and bonds. We based that prediction upon the then completed state appraisals of the railways in Michigan, Wisconsin, Washington and Minnesota.

The valution engineers of the Interstate Commerce Commission have recently reported tentative findings respecting several railway systems that confirm the prediction made eleven years ago. For example, the tentative estimates of the I. C. C. engineers show that it would have cost $410,000,000 to reproduce the Chicago, Rock Island & Pacific Ry. as of June 30, 1915. Since that date the company has spent nearly $18,000,000 for additions and improvements, thus bringing the total up to $428,000,000 exclusive of stores and supplies and working cash capital. The total capitalization of this railway is about $346,000,000, or 20 per cent below the prewar cost of reproduction.

Since this fact became known the market value of the stock of the Rock Island has risen somewhat. We believe that a far greater rise will occur when the investing public realizes that the decisions of the U. S. Supreme Court make it certain that railway and public utility property must be valued at present prices and not at prewar prices.

Since present construction prices are about 80 per cent in excess of prewar prices, the cost of reproduction of the Rock Island system would be fully double the par value of its outstanding stock and bonds. The same holds true of the New York, New Haven and Hartford Ry., and of nearly all the other large railway systems.

Curiously enough the investing public has not yet seen the full economic significance ot the railway bill that has just been signed by the President. That bill makes it incumbent upon the Interstate Commerce Commission to divide the country into "regions" and to fix railway rates so as to yield net earnings of at least 5 per cent upon the "value" of the railways in each of these "regions." But what constitutes "value"? The U. S. Supreme Court has plainly indicated in the "Minnesota rate case" that "value" is not "original cost" but "present value." In that celebrated case the court sanctioned a value equivalent to the cost of reproduction new less accrued depreciation. The accrued depreciation of railway properties has ordinarily been about 20 per cent of the cost of reproduction. Hence it may be safely concluded that the present minimum "value" of the railways will be cost of reproduction at present prices less 20 per cent depreciation. But to this something will be added for "going concern value." Charles A. Prouty, director of valuation for the I. C. C., has announced that an allowance of about 7.5 per cent of the value of the physical property should be made to cover the "going concern value" of the Rock Island system. The railway company is contending for much more than 7.5 per cent.

It is our opinion, based upon the decisions of courts, that the railways will ultimately secure a "going concern value" that will fully offset their accrued depreciation; hence that they will be granted by the U. S. Supreme Court a value practically equal to the cost of reproduction at prevailing construction prices. If so, the I. C. C. will be forced by the present law to raise railway rates till they yield at least 5 per cent net upon the cost of reproducing the railways at construction prices prevailing at the time the rates are fixed.

In any event it is clear that the present market prices of railway securities are destined to rise enormously within the next few years. Coincidently there will occur a great era of railway construction and improvement.

Since the foregoing was written the U. S. Supreme Court has rendered a decision that strengthens its former position relative to "value for rate making purposes." The Kansas Southern Ry. sought to mandamus the Interstate Commerce Commission to take testimony relative to the cost of condemning its right of way and station lands, the object being to secure a valuation in excess of the present value of contignous lands. The Supreme Court has granted the mandamus, thus, in effect, declaring its belief not only that the present value of railway lands must be taken but also that thereto must be added an estimated condemnation cost. In the Minnesota case the Supreme Court excluded this element of condemnation cost. The exclusion was a palpable error, as we pointed out at the time, ten years ago. Now the court has evidently rectified that error.

It is estimated that this decision will add fully $3,000,000,000 to the value of rights of way and station grounds, which is about 15 per cent of the total capitalization of the railways. Important as is this victory for the railway companies, its greatest significance lies in the fact that the Supreme Court shows no sign of receding from its Minnesota rate case decision, but on the contrary, virtually revises that decision so as to eliminate the one inconsistency that it contained.

The chief engineer of the Rock Island is quoted by the daily papers as saying:

> "The full amount probably will not be allowed, but the roads and the government could get together on a compromise, and in any event the roads will be big beneficiaries. The government valuation board allowed Rock Island $51,000,000 as the value of right of way and land. This decision will allow us easily $51,000,000 more."

The Unprofitableness of Starving the Railways

The total capitalization—stocks and bonds—of all the railways in America amounts to about $200 per capita, or $1,000 for each family. Assuming net earnings of 6 per cent annually upon this capitalization, we have $12 per capita or $60 per family as the average amount that would be paid to stock and bond holders by the American people.

There are, on the average, two persons engaged in gainful occupation to each family, and their annual earnings exceed $1,000 each, or $2,000 per family. Hence 3 per cent of their annual income, or $60 a year, would pay the railways 6 per cent net earnings on their total capitalization.

When put this way it is evident that the public is not as vitally concerned in keeping the railways from earning liberal dividends, as many politicians and some railway commissioners seem to believe. Of vastly greater economic importance to the public is a railway service that is adequate. This was brought forcibly to the editor's attention last autumn while on a Pacific Coast trip. The growers of fruits and vegetables, from southern California to northern Washington, were shouting themselves hoarse for cars. The "peak load" of the crop moving season was too great for the available supply of rolling stock. The farmers had to suffer, and the public had to foot the bill of higher food prices than would have existed had enough rolling stock been available.

For ten years the railways have been starved for lack of capital. Capital has been insufficient because investors resented the rate regulation that held profits to a minimum in good years and provided no surplus to tide over lean years.

In their efforts to save a few paltry dollars annually for the average family, by holding railway rates to a minimum, railway commissions have brought a one-time growing transportation system almost to a point of stagnation. But a decade of folly has apparently ended, and there is reason to hope that its like will never be seen again.

Salary Increases for Federal River and Harbor Engineers.—At the request of the Federal Department of the American Association of Engineers, Senator Calder of New York has proposed an amendment to the Rivers and Harbors Bill which provides for a 25 per cent increase of salary for assistant engineers, junior engineers and chief clerks in the engineering department-at-large, employed in connection with the improvement of rivers and harbors or on the construction of fortifications. This bill has passed the House and is now in the hands of the Senate Commerce Committee.

A Formula for Predicting Average Prices

By HALBERT P. GILLETTE, Editor.

The writer has deduced a formula for predicting average wholesale commodity prices. Applied to each year from 1879 to 1919 inclusive, the formula gives results that agree very closely with the corresponding average price for each of those years. The formula is:

$$P = \frac{0.86MT}{CE}$$

P = weighted average wholesale price of commodities, or the "price index" as given by the Bureau of Labor.

M = total money (currency) in circulation on June 30 of the given year.

$T = \text{annual turnover of money} = \frac{C}{B}$

C = total bank clearings outside of New York City during the given year.

B = total individual bank deposits in the United States as of June 30, of the given year.

C = total population at the end of the given year.

E = productive efficiency of the average person.

The productive efficiency between the years 1879 and 1904 inclusive was:

$E = 1 + 0.012\ N.$

N = number of years from 1879 to the given year, up to and including 1914.

Since 1904 the productive efficiency, E, has been practically constant, so that for the years 1905 to 1919 inclusive E = 1.3.

Hence for the last 14 years the formula is:

$$P = \frac{0.67MT}{C} = 0.67mT$$

m = per capita money in circulation.

All the data relating to the variables in this formula for each year from 1879 to 1918 can be found in the Statistical Abstract of the U. S., which can be obtained for 50 ct. from the Superintendent of Public Documents, Washington, D. C.

The derivation of this formula will be given in a subsequent article, together with a full discussion of its economic significance. The reliability of the formula is established by its close concordance with the wholesale prices for the past 40 years.

Railway Earnings for 1919

From a forecast of the results of operation for the year 1919 recently made public at Washington, it appears that only 2¾ per cent was earned by the railroads of the country on their total capitalization.

In the following tabulation the 1919 earnings are compared with the average in the three year test period (1914-1917), on which is based the Government war guarantee of net income:

Item.	1919.	Test period average.
Revenue	$5,181,000,000	$3,395,000,000
Expenses and taxes	4,666,000,000	2,490,000,000
Net operating income	515,000,000	905,000,000

The following is the statisticians' estimate of the comparative cost of operating the railroads now and in the test period immediately prior to government control:

	1919.	Test period.	Inc. Per cent.
Wages	$2,600,000,000	$1,340,000,000	94
Coal	550,000,000	250,000,000	120
Materials	1,316,000,000	750,000,000	75
Taxes	200,000,000	150,000,000	33
Total	4,666,000,000	2,490,000,000	87

The net operating income for the year shows a deficit of $390,000,000, as compared with the Government guarantee.

Dirt Moving in Texas with the Fresno.—Fresnoes are extensively used in Texas in road grading. In this work the general practice is to let to a sub-contractor one mile of road for every team and a half or 3 or 4 miles to a 7-team outfit. The latter is handled by 5 men, with two additional men for grub bing and similar work. As a rule there is one plow to every three scrapers. Three mules are used on each fresno, and 4 mules on the plow. From 9,000 to 11,000 cu. yd. per month are removed by one of these 7-team outfits.

Compressed Air in Excavating for Building Foundations

By THOMAS A. BALDWIN,
Aberthaw Construction Co., Boston.

The use of pneumatic drills in rock excavation for foundations of buildings has become so common as to excite little remark. However, some details of the way in which this work has been handled in a construction job at Lockport, N. Y., by the Aberthaw Construction Co. of Boston, Mass., may be of interest. The excavation here included about 5,900 cu. yd. of rock, of which 3,600 yd. were in the basement of the building proper, 1,600 yd. in pipe line trenches, and 700 yd. in the pump shaft and tunnel. The rock is of lime-stone formation, with a depth varying from 4 to 10 ft. of shale overlying the solid rock. A hard sandstone was found 16 to 20 ft. below the surface, but was not reached by the excavation except in a small portion of the area.

For the building proper the rock cut varied in depth from 12 in. to 8 ft. No data were kept on the number of holes drilled, the spacing depending entirely upon the character of the cut and its depth. But in the beater room basement, where the floor was first excavated level regardless of drains and ditches, the depth of cut was more uniform, varying from 4 to 6 ft. Here, the holes were drilled approximately 4 ft. on centers, and about 6 in. deeper than the final floor level.

The standard charge for the 4-ft. holes consisted of two sticks of 40 per cent dynamite. This charge was increased at places where the rock appeared to be more solid, and where deeper holes were drilled. The maximum charge used in any hole was five sticks. In some cases, the charge was as low as one-half stick.

Two drills were sufficient for drilling in advance of muckers. The average "output" reached was about 14 ft. per hour for each drill in this type of excavation; the maximum for one day went as high as 23 ft. per hour per drill. With this speed of drilling, the average rock excavation came to 85 cu. yd. per week, but this average was maintained only where the work was straight ahead, as in the beater room basement. Where ditches and angular cuts were needed, requiring very close line drilling in order not to disturb the adjoining rock, a much greater amount of drilling was necessary, and correspondingly smaller charges of dynamite were used. This condition prevailed throughout the greater part of the entire rock excavation.

One air compressor of the Ingersoll-Sergeant type was used, this being a single-stage machine with an air cylinder of 12 in. by 10 in. stroke, running at a normal speed of 250 revolutions per minute. This machine had a capacity of 324 cu. ft. of free air per minute. Air was delivered into a vertical receiver, 42 in. in diameter and 8 ft. high, from which point it was led to the holes as needed. The compressor was driven by means of a belt from a 50 hp. induction motor, running at 750 revolutions per minute on 25-cycle, three-phase current at 440 volts.

The air compressor and motor were bolted to a concrete foundation, and housed in a shanty located conveniently to the various buildings under construction. The compressor was water cooled with a constant stream of fresh water running through the jackets. The air receiver was equipped with an automatic regulator set at 85 lb. pressure. This unloaded the compressor when the air in the tank reached the predetermined pressure.

Along the full length of the buildings, a line of 2-in. main feed pipe was placed, fitted with tees at every 50 ft. From these tees, 1¼-in. lines were carried to various parts of the building as needed. For protection against mechanical damage, the main feed line was laid just below the ground level.

Five jack hammers were used, arranged to receive 1-in. hexagonal steel drills. Two of these hammers were later equipped with special pistons, rifle-bars, valves, etc., to fit them for operation with water. This was for the purpose of excavating in the tunnel.

The air drills were served by ¾-in. air hose of 7-ply plain and anti-peel type, in standard 25-ft. lengths, and fitted with couplings. The drills, which were in lengths of 2, 4 and 6 ft., were equipped with rose bits.

Very little trouble has been experienced with the air compressor, due largely to the fact that it was well placed, and well protected. The drills also have withstood wear in a very satisfactory manner, the breakage being confined to minor parts, of which sufficient spares were usually in stock. The hammer parts which required the most frequent replacement were the steel holders, side rods, rotation pawls, plungers and springs.

The drill bits themselves gave a good deal of trouble from breakage, in spite of the fact that they were 1-in. hexagonal, while it was thought that ¾-in. would have been sufficiently heavy for this character of rock. Due to the fact that the company had a skilled blacksmith on the job, however, who could handle the welding of these drills, the stock of drills which had to be carried was not excessive.

Protection from flying splinters of rock when shooting the charges was very carefully worked out, due to the proximity of adjoining property, as well as the fact that men were working all over the plant. Saplings of green rock elm, 20-ft. long, and ranging from 6 to 10 in. in diameter, were matted over the charged holes, and tied together with ¾-in. steel chains. These proved adequate to prevent trouble from this source, and to forestall complaints from neighbors and others who might have been seriously inconvenienced if such precautions had not been taken.

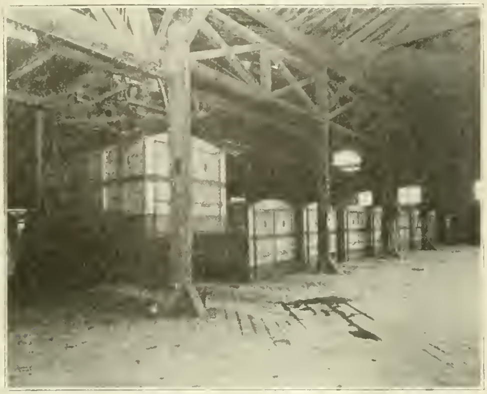
Durability of Steel and Pressure Creosoted Wooden Dredge Hulls

Some interesting information on this subject has been furnished The Military Engineer by Mr. C. W. Durham, principal assistant engineer, Rock Island district. He states that three 18-in. hydraulic pipeline dredges built by hired labor at the United States dry dock at Keokuk in 1912 with steel frame trusses, untreated timber bottoms, creosoted timber sides, reinforced concrete decks, showed in December, 1918, no evidence of rot, rust, or distortion, and no hull repairs have been necessary. These dredges have had seven seasons of moderate use, usually with double crews working 16 hours a day. In comparison, three dipper dredges of steel construction, while in excellent condition, have required scraping and repainting at considerable cost. In 1908 and 1909 there were built at the various yards in the Rock Island district 79 standard barges of Douglas fir, creosoted by the open-tank or dipping process. After 10 years' service, 40 of these were reported good, 37 fair, and 3 bad. Most of the barges classed as "fair" showed some decay. The principal deterioration, however, was the abrasion and wear of the decks. In 1911 and 1912 there were built 90 standard barges of Douglas fir, treated with coal-tar creosote by the pressure process, 10 pounds to the cubic foot. Of these, 80 were reported to be in good condition Dec. 31, 1918, showing no evidence of decay; 10 were reported fair, and none bad. All barges can be placed in the "good" class at small cost for repairs. The experience in the Rock Island district does not show that creosoted lumber is weakened by the pressure process, although it may become less resilient. Mr. Durham believes that creosoted lumber will not decay to the depth of the creosoted penetration, but that when the abrasion goes deeper than that decay is invited.

Bonus Plan for Construction Superintendents and Foremen.—The H. G. Christman Co., general contractors, is using a bonus system for rewarding its superintendents and foremen. At the completion of the job, comparison is made between the estimated and the actual costs, and the superintendent is paid a bonus in proportion to the savings he has made. He in turn shares the bonus with the various foremen working under him, on a predetermined basis. At the beginning of the job each foreman is given an estimate of the labor cost, only, on the work that will fall to his men, so that he can always tell whether the work is being done within the estimate, and yet he does not have details as to the total cost of each part of the job. The bonus is made a liberal one so that a strong inducement is offered to those in direct charge of operations to put forth every effort in securing a good output from the workmen and in developing more efficient methods. The success of such a bonus system hinges upon adherence to fair standards when the estimates are prepared, so that under careful supervision savings worth while can be made.

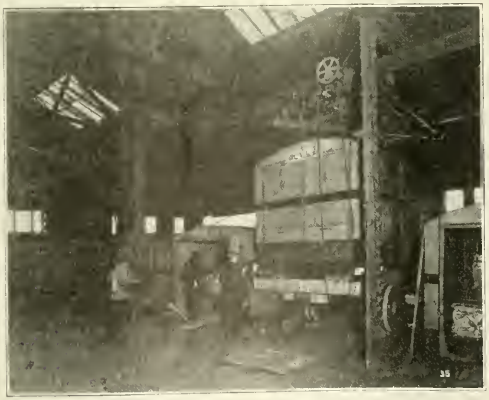
Motorized Railway Freight Terminals at Cincinnati

Between all the widely distributed freight houses of the various railroads in terminals box cars are used in transfer or connecting line service. When so used they are in various sections termed "trap," "transfer" or "ferry" cars. For instance, in any city with seven non-competing railroads radiating to different sections, each line receives daily in its city cars some freight for each of the six connections. Numerically this means 42 cars in transit to and 42 cars in transit from, a total of 84 cars. But due to yard interchange delays these cars average a third day arrival instead of a second day arrival; hence, 252 cars are assigned daily to such service. Thus 75,600 car days are required annually.



Chesapeake & Ohio Fourth Street Inbound Freight House at Cincinnati, O. Platform at Street Level. Loaded Body, Sealed and Raised by Electric Hoist, Awaiting Dispatcher's Order for Conveying to Connection.

Industrial expansion at any city with seven initial lines, has, as a rule, outgrown station facilities, and railroads, for economy's sake, have strategically established sub-stations along their rights-of-way as traffic influences for shipments from outlying districts. Since all the freight from these outlying districts has to be brought to main stations to be consolidated in cars for dispatch from such main station to destination points, and since all of the freight for these sub-stations comes out of main station cars on arrival, trap cars are necessary in this main sub-station service of each line. The number of cars so used is a multiple of stations. If, as above stated, each of the seven lines has three stations, 42 cars are required, with movement delays as great as connecting line cars; therefore, the wasting of an additional 37,800 car days. This explains one of the reasons for car shortage and an operating abuse which is claimed to have been obsoleted by the success of a motor terminals installation at Cincinnati, O. An interesting description of this installation was given by Mr. B. F. Fitch, President, Motor Terminals Co., New York and Cleveland, in a paper presented Feb. 26 at the convention of Material Handling Manufacturers' Association. The matter following is taken from his paper:

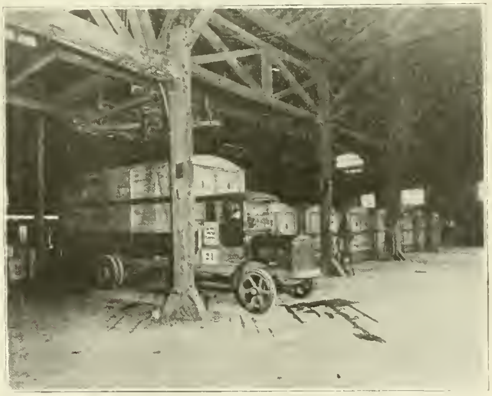


Rear View of Body Being Placed on Chassis. Also Shows Empty Bodies Receiving Direct Run of Freight.

Briefly, this installation consists of overhead rails, electric cranes, electric hoists, motor trucks and a plurality of interchangeable motor truck bodies. The system of operation requires an empty body for each station movement demand of railroad on its inbound main station platform. At the larger stations there are several locations for such body settings, thereby decreasing the trucking distance for freight. As the freight comes from the cars, it is trucked to the nearest location containing a body carded for any connection or any substation.

When loaded, these bodies are sealed and under telephone order of a joint dispatcher, employed by the railroads, mechanically loaded onto trucks and thus routed over city's streets to connection.

On arrival at the outbound platform of the connecting line, the body is mechanically removed and an empty body, previously unloaded, is similarly put onto a motor truck chassis for delivery to the inbound platform of that house, where the operation is repeated and another loaded body forwarded in the same manner to some other freight house.



Truck Backing in With Empty Body for Loading.

If the load happens to be to a sub-station, it remains on the platform until the dispatcher is advised by the agent at the sub-station that the return load is available. Then the loaded body of inbound freight to that sub-station is forwarded and the motor truck exchanges same for the previously reported load of outbound freight to be delivered at main station, where it is consolidated with other city freight in line cars made up daily to innumerable other destination points.

From the above it is evident that all freight, except possibly the portion arriving during the last hour of the station operating day, whether between main and sub-stations or between main stations of the various railroads, is currently loaded and out of the terminal. Previously this freight by trap cars suffered an average three days delay and the shuttle movement of these individual cars over terminal rails interfered with the group movement of complete cuts of station cars. Hence, the congestion which previously made Cincinnati notorious as a check-valve in rail routings.

In May, 1917, the Big Four R. R. permitted a test installation between its five main and sub-stations. The innovation was an early success, but the other roads were skeptical of its enduring efficiency. In the early months of 1918 a special committee was appointed to analyze the entire terminal and, based upon Big Four accomplishments, recommend what economies and benefits could be anticipated from completely motorizing Cincinnati's terminal.

The summary of this comparative report prophesied the following, and as a result contracts were negotiated:

Annual economy, $61,652.
Advance movement of freight, 52.4 hours.
Increase inbound platform floor area, 14.8 per cent.
Increase outbound platform floor area in ratio with station operation.
Increase main station trackage, 21.4 per cent.
Increase main station realty, 122,660 sq. ft.
Release 66,862.5 cars for line service per annum.
Extension of present labor, 30.4 per cent.
Eliminating the rehandling of 86,976 tons of freight lessens railroads liability of loss and damage.

In 1919 equipment orders were entered and the railroads commenced station changes and superstructure construction. The terminal is not fully equipped, for both the railroads and the Cincinnati Motor Terminals Co., which is operating this equipment on contract basis for the railroads, have suffered exasperating delays. However, in a recent analysis of accomplishments it is proven that, due to increased operating costs of railroads the prophesied 17.1 ct. per ton economy is in practice actually a saving of 35.2 ct. per ton and, therefore, the annual economies will be $126,507 instead of $61,652.

For the railroads alone at Cincinnnati the interchange is furnished by the Cincinnati Motor Terminals Co. between stations within a 10-mile zone at rates averaging less than $1 per ton. The minimum is 80 ct. and the maximum $1.25.

The Status of the Engineer in Railroad Service as Affected by Esch-Cummins Bill

By A. M. VAN AUKEN.

Under the Esch-Cummins Bill the income of the railroads is guaranteed to be not less during the first six months of private operation than the rental received during government control. The duty is laid on the Interstate Commerce Commission of fixing transportation rates to go into effect within or at the close of the six months' period which rates shall provide above operating maintenance costs a return of 5½ per cent upon the value of the properties.

It is provided also that until Sept. 1, 1920, wages or salaries of employes or subordinate officials shall not be less than that fixed by any agency during government control and in effect immediately preceding March 1, 1920.

These two clauses have a tendency to allay unrest and to give confidence in the ability of the carriers to pay existing salaries and to require a period of reflection before other than minor changes are made.

As the rule of ratemaking calls for rates to be so fixed as to return an income on the investment, which is not that of individual roads but of all roads in a district, there is the incentive to each manager to better his own operating ratio. It would seem that with a return assured there should be a tendency toward a higher standard of maintenance of roadway, equipment and facilities. Wooden structures will more rapidly give way to concrete and steel. More and better ballast will be used. Alinement and gradient will be more to exactness and less to eye. These things will be done because the average carrier will be assured an income which will provide for maintenance needs. All this calls for more service which only the engineer can render.

The new law removes the "Twilight Zone" from ratemaking, by providing that in all cases where intra-state rates or regulations are in conflict with those ordered by the Interstate Commerce Commission, the carriers shall obey orders of the commission, regardless of state laws, decisions or orders.

The portion relating to disputes between carriers and their employes and subordinate officials is somewhat involved in its wording, but as explained by Chairman Esch, it permits the formation by agreement between the carriers and their employes of voluntary adjustment boards with jurisdiction over disputes involving grievanees, rules and working conditions. "There is further established a railroad labor board composed of nine members appointed by the President, by and with the advice and consent of the Senate, three from nominees offered by carriers, three from nominees offered by the employes of the carriers, and three to be directly appointed and to be representatives of the public. The railroad labor board has exclusive jurisdiction over disputes involving wages, and also of disputes involving grievances and working conditions in case no adjustment board has been formed by the carriers and employes who are parties to such dispute. The railroad labor board has appellate jurisdiction upon its own motion or upon request of an adjustment board, in case such adjustment board is formed but fails to decide such disputes. * * * The provisions of the conference bill permit action by the railroad labor board not only upon application of either party or by petition of unorganized employes but also upon the adjustment board's or the railroad labor board's own motion.

Chairman Esch's statement indicates that it is now possible for such an organization as the A. A. E. to bring the grievances of the professional man in railroad service before the railroad labor board and secure a ruling on such principles as were enunciated by the Compensation Committee of the Chicago Chapter in its report last year.

The authority given the Interstate Commerce Commission to permit consolidations; to require joint use of terminals and to fix rates which will give a return on the value of the properties all call for the determination of value of properties consolidated or used. Only the work of the engineer can determine value.

It is by no means certain that freight rates of the near future will be based on general cost as now, which is but vaguely known, or upon the previously determined cost of the actual cost of service. For instance, it is said to cost for switching service alone to switch a car to its destination after the breaking up of a freight train as follows in the cites named:

New York	$35.00
Chicago	10.35
Binghamton, N. Y.	1.80
Salamanca, N. Y.	3.80

Will the public permit the great cities to graft on the smaller as they have done? Will the motor truck bring freight from outer yards and displace switching service?

Whatever it is, the engineer will design it and the engineer must gain credit, and it is to be hoped, reward.

The clause relating to automatic stop and safety control in the compromise bill authorizes the Interstate Commerce Commission to order the installation of such devices, such installation to be completed within two years from date of order.

In this compromise bill the Railroad Committee of the Chicago Chapter takes some pride. It caused letters to be written to all members of the conference committee opposing the labor settlement provisions of both old bills and the principles advocated in those letters are in harmony with those in the compromise bill. It caused letters to be written to the committee criticising the provision for Automatic Stop in the Esch bill owing to the short time, one year, allowed for installing, advocating the allowing of one year for experimenting and two years for installing. The compromise bill provides "not less than two years."

New Outline Base Map of United States. An outline base map of the United States on the Lambert Zenithal Equal-Area Projection, scale 1:7,500,000, dimensions, 19¾ by 25¾ in., has been issued by the U. S. Coast and Geodetic Survey. The map covers the whole of the United States, including the northern part of Mexico. Only state names and boundaries, principal rivers, capitals, and largest cities are shown, the chief object being to furnish a base map for political, census, or statistical purposes, on a projection in which the property of equivalence of area is one of the essential features. It is the first publication of a projection of this type by the survey. Besides the useful property of equal area, the projection has smaller scale and direction errors than the polyconic projection which has frequently been employed for the purposes above referred to. The projection should not be mistaken for the Lambert Conformal Conic Projection, which has special properties of its own and is published in a base map of the United States, scale 1:5,000,000. The latter projection, like the polyconic, is not an equal-area projection. The center used for the Lambert Zenithal Projection is latitude 40° and longitude 96°, corresponding closely to the geographical center of the United States, which has been placed approximately in latitude 39° 50′ and longitude 98° 35′, a point near Lebanon, Smith County, Kans.

Stresses in Railroad Track

The Special Joint Committee of the American Society of Civil Engineers and the American Railway Engineering Association, organized on June 3, 1914, to report on stresses in railroad track, has presented its second progress report in the February Proceedings of the American Society of Civil Engineers. This voluminous report of some 165 pages is the result of about two years additional work by the committee and contains a large amount of valuable matter. Some of the more important facts of the report are abstracted below.

It was early realized by the committee that an adequate report on stresses in railroad track must be based largely on experimental data derived from extensive tests on standard railroad track, and that in view of the complexity of the action of track under load and the variability of the conditions to be found in track and load the work of conducting experiments and reducing the data would necessarily require a large amount of time and effort. An important element in the work, which has involved expenditure of time, effort and money, has been the development of methods of conducting the tests and of devising the instruments and apparatus. It has been recognized from the start that in obtaining data on the action of track under the variable conditions of both track and load, great refinement of method was not possible and it was important to make tests under conditions of railroad service as nearly normal as is possible, utilizing also of course the data of laboratory investigations where conditions would not permit satisfactory experiments in the field.

The work reported includes the results of tests with one type of freight locomotive and one type of passenger locomotive on the St. Louis-San Francisco Ry. to determine stresses in rail in relation to speed and counterbalance effect, and also the results of similar tests with one type of freight locomotive on the Illinois Central R. R. The report gives the results of tests on the Illinois Central R. R. and the Chicago, Milwaukee & St. Paul Ry. to determine the depression of track under given loads and to find the depression and flexure of ties and their action under load for a variety of conditions found in track. The tests conducted in the Laboratory of Applied Mechanics of the University of Illinois with a view of finding the methods and principles involved in the transmission of pressure from one or more ties downward and laterally through ballast materials are reported and an analytical consideration of the transmission of pressure is given.

Locomotives Used in Tests.—In the tests on the St. Louis-San Francisco Ry. two types of locomotives were used, the Santa Fe type freight locomotive and the Pacific 1060 type of passenger locomotive. Slight variations were made in these locomotives by lightening reciprocating and rotating parts of the Santa Fe and Pacific types and by changing the position of the equalizer pin of the Pacific type. The Santa Fe type locomotives were new locomotives, having been in service less than a year. The Pacific type locomotives had been in service about two years.

The diameter of the drivers in the Santa Fe type was 60 in. and that in the Pacific type 73 in. The crank pin was 15 in. from the center of driver in the Santa Fe type, and 14 in. in the Pacific. The corresponding distance for center of counterweight was 16½ in. in the Santa Fe type and 20¼ in. for the main driver and 25¼ in. for the other two drivers in the Pacific type.

Table I gives the weights of the reciprocating and rotating parts of the Santa Fe locomotive as given by the Mechanical Department of the St. Louis-San Francisco Ry., together with the calculated required counterweights, the amount of counterweight used and the excess or deficiency of counterbalance by the method of calculation used by the railroad company. It will be noted that 60 per cent of the weight of the reciprocating parts is included in the counterbalancing calculations and that this weight is divided among four drivers and not among all five, a matter which affects the vertical dynamic augment only as the overbalance or underbalance of the several wheels for rotational parts is affected. Table 1 also gives the excess or deficiency of counterweight needed to balance the rotating parts only, since this excess or deficiency is the principal factor affecting increase or decrease in vertical pressure on the rail.

There may be of course some question concerning the amount or proportion of the weight of the main rod which contributes to the rotational effect. The excess or deficiency of counterweight needed to balance the rotating parts only, as given in Table I is the value usually considered in designing practice, and is found without taking into consideration the effect of the rods and pin not being in the same vertical plane with the counterweight of the driver. The method for taking this variation of position of the dynamic forces into account involved adding to the weight of the side rod and its part of the pin 11 per cent of the weight of these parts as being approximately the effect for the average of the dimensions of the three types of locomotives used in the tests, and to the weight of the main rod used and its part of the pin 23 per cent of the weight of these parts—this increased weight being considered to represent the weight to be used in determining the condition of counter-balance in the plane of the counterweight. Applying these percentages to the parts affecting the main driver, the weight of the main rod coming on the crank pin and that of the side rod and also the parts of the crank pin in the main rod and the side rod, the underbalance of the main driver is found to be 1042 lb. instead of 746 lb.—a very great deficiency. For the other drivers the effect is not so great; there is a reduction in the amount of overbalance of 27 lb. for Drivers 1 and 5 and 67 lb. for Drivers 2 and 4. It is not known how closely the weights of the locomotives used agree with the weights given in Table I; the indications are that there are uncertainties in the weights and in their positions.

The ties were the 6 by 8-in. by 8-ft. oak ties which had been specially prepared for this stretch of track. They were spaced approximately 20 in. apart, 20 ties to 33-ft. rail. On the section used in the test there was 12 in. of stone ballast. The track had not been tamped for some time and was not in the best condition of line and surface, but it was used in the condition found.

The Conduct of the Tests.—The instruments used to determine the strains in the rail were the stremmatographs described in the first progress report. Four stremmatographs were used simultaneously. The methods employed were generally the same as those described in the previous progress report. Figure 1 shows the position of the instruments as used in the tests on the St. Louis-San Francisco Railway. Set-ups a, c, and d were on the same rail, and Set-ups b and e were on the adjacent rail. It will be noted that in two set-ups, three instruments were on the rail on one side of the track and the fourth was on the rail of the opposite side. The instruments were spaced two, three, and four tie spaces apart.

In the tests on the St. Louis-San Francisco Ry., as it was a single-track stretch of railroad, the two sides of the track were presumably the same with respect to ballast and tamping.

In the principal tests made with the Sante Fe type locomotive, three stremmatographs were placed on the rail at the right side of the locomotive and one on the rail at the left side (see Fig. 1 location a). In the tests to determine the stresses developed at the two sides of the locomotive, the four instru-

TABLE I—WEIGHTS OF ROTATING AND RECIPROCATING PARTS, IN POUNDS—SANTA FE TYPE LOCOMOTIVE OF THE ST. LOUIS-SAN FRANCISCO RY.

Reciprocating Parts.

Piston	803
Cross-head	860
48% main rod, weight on cross-head pin	657
	2,320

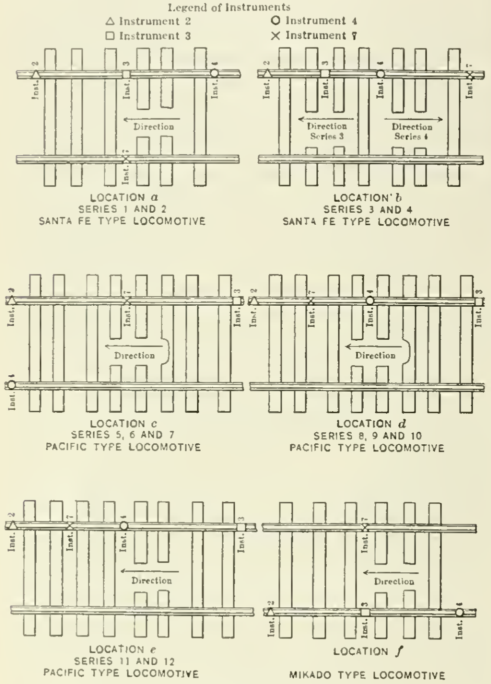
$$\frac{0.60 \times 2,320}{4} = 348$$

Rotating Parts.

Driver number	5	4	Main	2	1
60% of weight reciprocating parts	348	348	.....	348	348
Main rod, weight on crank pin	.....	.....	735	.....	.....
Side rod, weight on crank pin	190	583	740	504	190
Crank pin	155	162	420	162	140
Crank pin hub	189	196	305	196	189
One-half eccentric crank	.....	.....	60	.....	.....
Total	882	1,289	2,260	1,210	867
Equivalent weight required at center of counterweight, average taken for two corresponding wheels	794	1,135	2,054	1,135	794
Weight used	812	1,156	1,376	1,156	812
Difference between weight required and weight obtained	+ 18	+ 20	—678	+ 20	+ 18
Equivalent difference at crank pin circle	+ 20	+ 22	—746	+ 22	+ 20
Overbalance or underbalance at crank pin circle for rotating parts only	+368	+370	—746*	+370	+368

*This becomes 1,042 lb. if the effect of the rods and pin not being in the plane of the counterweight is considered to be as described in the text.

ments were placed on one rail, and part of the tests were made with the locomotive running in one direction and part in the other (see Fig. 1, location b). In the tests with the Pacific locomotive, the four instruments were placed on one rail (see Fig. 1, locations c, d, and e). In all runs steam was shut off as the locomotive approached the test section of track. The speeds were read from a speedometer in the cab connected with the tread of the trailer, the instrument being checked up by timing runs over a measured length of track. For each set of tests the order of speeds for consecutive runs was the same, three or four speeds being used together, and the record of each three or four runs at these speeds was made on one set of discs; new discs were then placed in the instruments.



LOCATION *a*
SERIES 1 AND 2
SANTA FE TYPE LOCOMOTIVE

LOCATION *b*
SERIES 3 AND 4
SANTA FE TYPE LOCOMOTIVE

LOCATION *c*
SERIES 5, 6 AND 7
PACIFIC TYPE LOCOMOTIVE

LOCATION *d*
SERIES 8, 9 AND 10
PACIFIC TYPE LOCOMOTIVE

LOCATION *e*
SERIES 11 AND 12
PACIFIC TYPE LOCOMOTIVE

LOCATION *f*
MIKADO TYPE LOCOMOTIVE

Fig. 1—Position of Stremmatographs in Tests.

The position of the counterweight with respect to one instrument was observed for each run. The effort was made to keep the counterweight at the same position with respect to the instrument for the three or four runs covering the three or four speeds used, and then to slip the drivers sufficiently to change the position of the counterweight about one-fourth of a revolution. The slipping of the drivers in stopping and starting, however, changed the position somewhat. The instruments were placed about one driver diameter apart so that for each instrument there was a different position of counterweight. Altogether the tests give a general distribution of position of counterweight over the entire revolution.

Tests on St. Louis-San Francisco Ry.—Table II gives information on Series 1 to 12 made on the St. Louis-San Francisco Ry. The injury done to rails by the Santa Fe locomotives soon after they were received from the builders had given the railroad company some concern, and the opportunity was taken to make tests with what was evidently a poorly balanced locomotive. The weight on the trailer of the Pacific locomotive seemed excessive, and for a wheel well away from other wheels the stress developed in the rail would be expected to be high. The bearing of the trailer at times had run hot. The tests were made to obtain information on the effect of speed and counterbalance with this type of passenger locomotive.

In Series 1, the order of runs in the tests was 5, 25, and 40 miles per hour for Locomotive No. 22, and 25, 50, 25, and 50 miles per hour for Locomotive No. 28. For Series 2, two sets were run, the first at 5, 25, and 40 and the second at 25, 50, 25, and 50 miles per hour. In Series 3 and 4 the order 5, 25, and 40 was used. For all series with the Pacific type locomotive, the order was 5, 45, and 60 miles per hour.

The tests were not made in the order of the numbers of the series; instead, the locomotives were taken as the demands of traffic or matters of convenience permitted. In the discussion which follows the series are grouped for the consideration of effect of speed and counterbalance, effect of lightening rotating parts, stress under the two sides of the locomotive, and general comparisons.

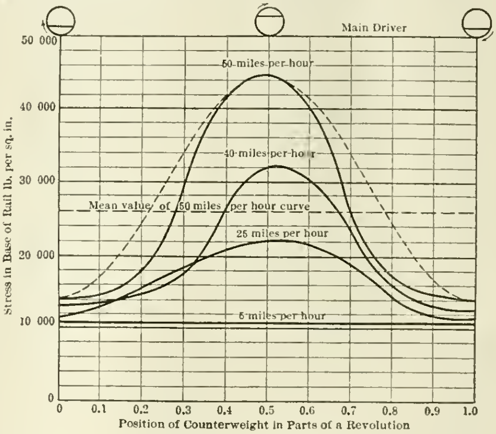


Fig. 2—Stress in Rail at Main Driver of Santa Fe Type Locomotive Throughout a Revolution.

Effect of Speed and Counterbalance of the Santa Fe Type Locomotive.—The typical effect of the combination of speed and counterbalance upon stresses in rail for Series 1 with the Santa Fe type locomotives is shown in Fig. 2, which gives sample curves for the main driver taken from the plotted results of the tests with the Santa Fe type locomotive from the data of the instruments on the rail on the right side of the locomotive only. The ordinates of the diagram represent stresses at the base of the rail in pounds per square inch. The abscissas represent the position of the counterweight at the time the wheel passed over the instrument with respect to its down position, the scale being in fractions of a complete revolution of the wheel. The curves represent the average of the results of the several runs at each speed. For a speed of 5 miles per hour the values are represented by a straight line, since the variation from it is small. As the driver is underbalanced, in general the greatest stress in the rail is developed when the counterweight is at its high position. At a speed of 50 miles per hour, it is noted that the maximum value of the curve is 44,700 lb. per square inch and the minimum value 14,000 lb. per square inch. The line marked "mean

TABLE II—TESTS OF THE ST. LOUIS-SAN FRANCISCO RY.

Series number.	Location of test	Type of locomotive	Locomotive number.	Position of pin in equalizer bar.	Remarks.
1	First location	Santa Fe	22, 28	....	General series with locomotive as received from builders.
2	First location	Santa Fe	19	....	Reciprocating and rotating parts lightened.
3	Second location	Santa Fe	22	....	Instruments all under right side of locomotive.
4	Second location	Santa Fe	22	....	Instruments all under left side of locomotive.
5	First location	Pacific	1061	Rear hole	Locomotive with stoker added.
6	First location	Pacific	1061	Middle hole	Locomotive with stoker added.
7	First location	Pacific	1063	Rear hole	Rotating and reciprocating parts lightened.
8	First location	Pacific	1063	Middle hole	Rotating and reciprocating parts lightened.
9	First location	Pacific	1067	Middle hole	General series.
10	First location	Pacific	1065	Rear hole	General series.
11	Second location	Pacific	1066	Middle hole	General series.
12	Second location	Pacific	1067	Rear hole	General series.

value of 50 miles per hour curve" is the average ordinate of the curve. The variation above and below this line may be considered to be due largely to the lack of balance of the rotating parts.

The difference between the mean value of the stress found from the curve for 50 miles per hour and the stress at 5 miles per hour may be considered to be largely the effect of speed without reference to effect of rotating parts (quite frequently called impact effect or speed effect), though part may be due to lack of balance of rotating parts. The dotted line of the figure was obtained by the use of the common formula for the vertical pressure of a rotating part, the calculation here being modified to touch the curve for 50 miles per hour at its high and low points. It will be noted that the form of the observed curves is more pointed than is the curve calculated by analytical methods, and also that the mean value of the curve is generally below the median point of the curve. These differences are characteristic of many of the tests, though it appears that there are as many cases where the observed curve is less pointed than the analytical curve as for more pointed curves.

General Observations on Counterbalance Tests.—It is evident that there is a decided advantage to the track in making the counterbalance of the several drivers differ but little from each other and from that condition which will give the best results, even though opposing conditions of counterbalance in the main driver and the adjoining drivers may have some neutralizing effect. An underbalance on one driver and an overbalance on an adjoining one will give a very undesirable cumulative effect.

It is of course to be expected that when the locomotive is working the downward pressure of the main driver will be increased over that obtaining when the steam is shut off as was the case in the tests here discussed.

For the Santa Fe type locomotives tested the stresses at the main driver were much greater than at the other drivers.

Considering the stresses developed in the tests it is not strange that great injury to track is done by poorly balanced locomotives run at high speed. Even at lower speeds, where kinking of rail does not result, the punishment of the track is much greater than will be caused by well-balanced locomotives. The effect of counterbalance and speed is to add greatly to the load to be carried by rail, tie, and ballast.

Effort may well be made to reduce the counterbalance effect on stress in track by use of the best methods of design of locomotive and by the use of material which will permit a minimum of counterbalance effect in both rotating and reciprocating parts.

It is important that care be taken to determine the actual weights and position of counterweights and the actual properties of the side rods and connecting rods. Care should be taken to learn whether the assumed division of load among the drivers in the completed locomotives is obtained.

Locomotives will give very different stresses in rail at the different wheels according to the wheel spacing, the division of load, and the effect of adjoining wheels.

It is apparent from analysis that for the spacing of wheels in the three types of locomotives the stress at the trailer under static load or at low speeds will be relatively large if the weight on the trailer is greater than, say, 75 per cent of the average weight on drivers; and the tests would indicate that for locomotives with even fairly good counterbalancing a discrepancy at low speeds between the stress at the trailer and the stress at a driver, due to a relatively heavy load on the trailer, may be expected to exist also at higher speeds.

TABLE III—STRESSES IN RAIL WITH SANTA FE TYPE LOCOMOTIVE OF THE ST. LOUIS-SAN FRANCISCO RY.—MAXIMUM, MINIMUM AND MEAN VALUES FROM CURVES FOR SERIES 1.

Stresses are given in pounds per square inch at base of rail.

Speed in miles per hour.	Position of counterweight.	Trailer.	Driver number. 5		Main.		1	Front truck wheel.
5	Mean value.	15,200	12,700	9,600	12,500	9,800	12,500	7,900
25	Up	......	15,600	11,400	24,500	12,000	15,600	
	Down	......	20,300	15,600	*12,000	15,600	18,700	
	Mean value.	18,000	17,700	14,300	17,300	13,500	17,300	11,900
40	Up	22,400	13,000	10,400	32,200	10,400	11,500	
	Down	15,600	20,800	21,300	10,900	17,700	20,800	
	Mean value.	18,000	17,200	16,100	18,700	13,500	15,300	11,100
50	Up	27,000	19,300	15,100	46,800	11,400	13,500	
	Down	20,800	28,600	26,500	11,400	25,500	26,000	
	Mean value.	23,900	23,100	18,900	23,900	17,900	19,100	15,600
Calculated additional stress due to counterbalance at 50 miles per hour		600	8,100	11,400	24,200	11,300	8,100	700

It was found that the wheels of the tenders of the different types of locomotives gave quite different effects of speed on the stress in rail.

Attention may well be called to the method herein used in calculating the stress in rail for a combination of driver loads. The method ordinarily adopted in taking into account the counterbalance effect uses the dynamic augment for the given driver only. In getting the stress-producing bending moment in the rail, however, it is necessary to take into account the dynamic augment also of the adjoining drivers. With the main driver underbalanced and the adjoining drivers overbalanced the pressures given by the adjacent drivers are especially influential and the effect of the combined loads should not be overlooked. It should be added, too, that the effect of counterbalancing upon bending moment in rail is different from the effect upon rail depression and pressure on rail—these must be calculated separately.

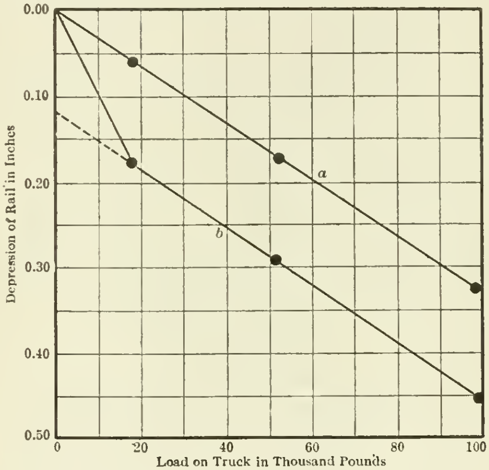


Fig. 3—Typical Load Depression Diagram.

In the discussion of counterbalance, and the calculation of the stress produced in the rail, no attempt has been made to go into the complications of the problem involved in the yielding of the locomotive springs and of the track acting as a spring, the effect of the rotating parts not being in the same plane, and other disturbing elements..

The tests were made on 85-lb. rail. It is felt that the effect of speed and counterbalance in producing stress in rails of other weight will follow in general the results found with the 85-lb. section. The increase in stress at a given speed over the stress at 5 miles per hour may be considered to be produced by additional loads at the drivers, due to speed and counterbalance, and the amount of these additional loads may be calculated by the use of the analytical methods outlined in the report. The loads thus found for speed and counterbalance effect may be used in judging of the effect of speed and counterbalance with rails of other sections. The calculations for stress in a section may be made on the basis of the analysis for bending moments given in the first progress report, the section modulus of the given rail being used in calculating the stress developed by the bending moment found.

It is evident that wheel spacing, distribution of load among drivers and trailer, and counterbalancing have a marked influence upon the stresses developed in rail and also in the track structure below the rail. Adequate consideration therefore should be given to these elements in designing locomotives if the track is not to be called upon unduly to carry loads and to resist stresses which are unnecessary or excessive. The uncertainty which may exist concerning exact conditions of counterbalance is a matter which warrants greater attention.

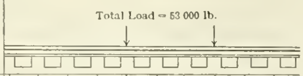
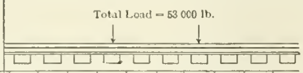
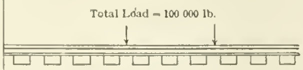
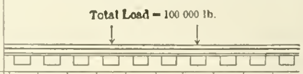
Depression of Track Under Load and Modulus of Elasticity of Rail Support.—Under the best conditions, with freshly tamped track, the depression at any tie may be expected to be nearly proportional to the load applied to the rail and likewise proportional to the load taken by the individual tie. For track not recently tamped or in poor condition there will be a slight play between the tie and the ballast along parts of its length, and part of the resistance before the tie takes bearing along its length will be due to the bending of the tie under the action of the lighter loads. These and other influences found in track not in the best condition make the line representing the relation of track depression to applied load vary from a straight line through at least a part of its length.

In Fig. 3, the relation between tie depression and load on tie for track in best condition is illustrated at (a). The vertical distances represent the depression of rail; the horizontal distances are proportional to the load on the track. This condition gives a cônstant modulus of elasticity of rail-support—the term defined in the first progress report as the pressure per unit of length of each rail required to depress the track one unit and which was found to be of considerable service in analytical investigations.

At (b) is illustrated the case where a light load produces considerable depression and greater loads result in additional amounts of depression which are proportional to the increments of load. The distance from the origin to the point where the line passing through the points intersects the vertical axis may be considered to represent in part the play or space between the bottom of the tie and its bed when the tie is not under load, though of course there is some bearing resistance by the tie for track depressions less than the amount of this intercept, and a part of the total play may be between the rail and the tie. In general the direction of the line through the points obtained by the several loads represents the load-depression relation and is closely parallel to the line found for well-tamped track. For general purposes the direction of this part of the line may be used in determining the value of the modulus of elasticity of rail-support.

The Cross-Tie and Its Action Under Load.—In railroad track of ordinary construction the cross-tie performs many important functions—it bears the load transmitted from the rails, makes a definite connection and spacing between the two lines of rails, transmits the pressure to the bed of ballast and by its properties as a beam distributes this pressure along its length. It thus is subject to compression under and in the vicinity of the rail, to tension or compression as a structural connection between rails, and to beam action in giving distribution to bearing pressures along its bed. Of these the last bears the most important relation to the problems here considered; the others will not be treated at this time.

Table IV.—Reactions in Terms of Load on Truck in Illinois Central R. R. Tests.

Location of Tests	Wt. of Rail Lb. per Yd.	Size of Tie in Inches	Depth of Ballast	Total Load = 53 000 lb. 									
B-1	85	6 x 8	12 in.		0.02	0.07	0.11	0.14	0.16	0.16	0.14	0.12	0.08
B-2	85	6 x 8	12 in.		0.01	0.08	0.15	0.17	0.18	0.18	0.15	0.08	0.00
B-2	85	6 x 8	12 in.		0.02	0.09	0.16	0 19	0.18	0.17	0.13	0.06	0.00
C-1	85	6 x 8	6 in.		0.05	0.11	0.17	0.18	0.17	0.15	0.11	0.05	0.01
C-2	85	6 x 8	6 in.		0.04	0.08	0.12	0.15	0.16	0.16	0.14	0.10	0.05
				Total Load = 53 000 lb. 									
K	125	6 x 8	24 in.	0.00	0.00	0.00	0.13	0.14	0.15	0.15	0.14	0.10	0.06
Cinder	85	6 x 8		0.00	0.00	0.04	0.10	0.15	0.19	0.21	0.17	0.09	0.05
				Total Load = 100 000 lb. 									
B-1	85	6 x 8	12 in.		0.03	0.07	0.11	0.14	0.15	0.15	0.14	0.12	0.09
B-2	85	6 x 8	12 in.		0.03	0.08	0.14	0.17	0.17	0.17	0.14	0.08	0.02
B-2	85	6 x 8	12 in.		0.05	0.10	0.14	0.16	0.16	0.15	0.13	0.08	0.03
C-1	85	6 x 8	12 in.		0.06	0.10	0.16	0.17	0.16	0.15	0.12	0.05	0.02
C-2	85	6 x 8	12 in.		0.06	0.10	0.13	0.14	0.15	0.15	0.13	0.09	0.05
				Total Load = 100 000 lb. 									
K	125	6 x 8	24 in.	0.03	0.06	0.10	0.12	0.14	0.14	0.14	0.12	0.09	0.06
Cinder	85	6 x 8		0.00	0.00	0 09	0.14	0.16	0.17	0.18	0.15	0.07	0.03

The cross-tie has many features which make it an acceptable part of ordinary track construction. It has great flexibility in meeting the varied and divers requirements of both ordinary and unexpected track and load conditions. It gives facility in providing, maintaining, or shifting the gauge, line and surface of track and in tie renewals and other changes in track, and is accepted as an economical and reliable element of ordinary track construction. It is known to be effective under very imperfect track conditions, being used where great variation of size and quality of tie, depth and quality of ballast, and condition of tamping of track may be expected to cause marked differences in the requirements put upon it. Quantitative data on the flexural action of the tie and the way its loads are distributed along its bed, as well as of its depressions under load, therefore should be of considerable value.

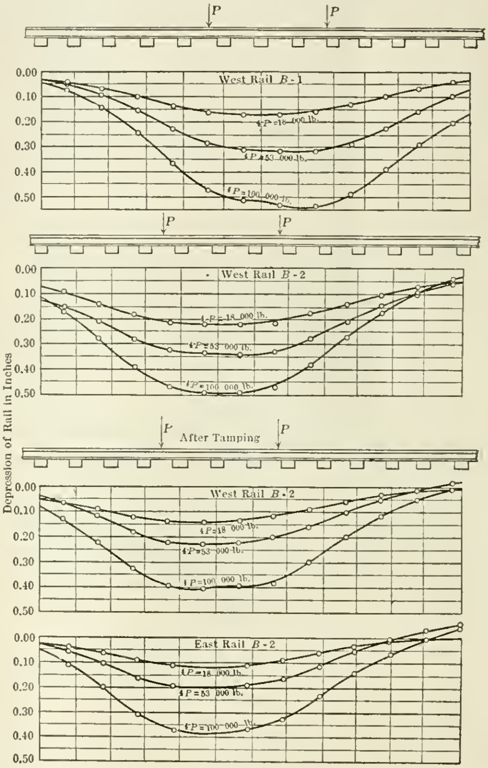


Fig. 4—Track Depression Profile on Illinois Central R. R.

Method of Testing Depression and Flexure and Bearing Pressure of Cross-Ties.—In measuring the depression and flexure of the ties a stiff wooden reference bar was placed under the rails between ties and close to the one on which measurements were taken. At each end of this bar was attached an iron cross-bar about 2 ft. long, the ends of which rested on two substantial stakes well driven into the ground, giving a firm support to the apparatus. These stakes were 7 ft. or more from the center of the track. Attached to the main bar were iron brackets (shown in Fig. 5) which projected over the tie. To each bracket was attached a piece of small angle iron; on this was bolted an Ames dial gauge which reacted against a tack driven at the mid-point of the width of the tie and served to measure the depression of the tie at that point. The arrangement of the attachment permitted adjustments vertically and horizontally.

Before applying a load the dials were adjusted to read zero. For each load applied the dials were read to the nearest halfthousandth of an inch. When the load was removed, a small depression was indicated by the dials and they were again set at zero. The same load was again applied, the process being continued until three consistent sets of readings were obtained. The average of these sets of readings was used.

In the tests on the Illinois Central R. R. nine dial gauges were used—five between rails and two on the outer side of each rail. This number of points was found not to determine the curve of flexure as accurately as was desired, and in the later tests made on the Chicago, Milwaukee & St. Paul Ry. the number of dials was increased to thirteen, seven between rails and three on the outer side of each rail; this improved the character of the data very much. In each case the dials next the rails were 1 to 2 in. away from the base.

The loads were given by means of loaded cars, as already described for the tests of track depression. The three loads on a single truck (two axles) were 18,000, 53,000, and 100,000 lb. on the Illinois Central R. R. and 37,000, 68,000, and 100,000 lb. on the Chicago, Milwaukee & St. Paul Ry. The leading wheels of the truck carrying the load were placed directly over the tie under test. The amount of the load considered to bear on the tie under test was taken from the results of the track-depression tests at the given location. The smallest load used was generally more than sufficient to overcome the play between tie and ballast, though of course this should not be taken to mean that under this condition the pressure on the bed of ballast is distributed uniformly along the length of the tie. The largest load used gave a tie reaction considerably less than that which would be caused at and between drivers by an ordinary Mikado or Santa Fe type locomotive. In the study of the data the largest load was generally used, though the smaller loads have given valuable information on the action of the tie.

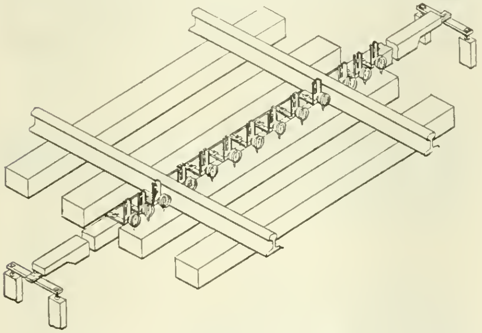


Fig. 5—Reference Bar for Test of Depression and Flexure of Tie.

The readings in all the tests checked very closely and the results are concordant. The effect of the rail bearing in compressing the fibers adjacent to the rail is unknown, but the reading of the dials next to the rail must include the general depression and bending of the tie and also a third element—the influence of the local downward compression of the tie due to the bearing pressure of the rail; the latter will have to be taken into account in interpreting the curves of flexure as related to bending moments and stresses.

Bearing Pressure and Bending Moment.—If the intensity of the tie reaction were directly proportional to the measured tie depression it would be easy to find the distribution of the tie reaction along the length of the tie by the use of the diagrams of tie depressions already given. Two variations from this law of distribution of pressure are known to exist: (a), due to the condition of ballast bed under the tie the unloaded tie may not touch its bed at all points and (b), the ballast may be more compact and more stiff at one point than at another.

A permanently formed depression at the rail acts to relieve the intensity of tie reaction there but increases the bending moment at this point when a load is applied which brings the tie down to full bearing. The second condition, that not giving direct proportionality between depression and intensity of bearing pressure, is particularly evident in freshly placed ballast. In well compacted ballast the variation from proportionality may be expected to be slight. Immediately after tamping, the bed may be somewhat stiffer at the point of tamping; as the effect of tamping disappears through the movement of the particles of ballast, the yieldability of the ballast under load, that is, the modulus of elasticity of the mass, tends to become more uniform along the length of the tie. By taking into consideration the effect of variations in these conditions the diagrams of tie depression and flexure will be found useful in indicating the range of variation of bearing pressure and bending moment.

The relative magnitudes of the bending moments at points along the tie is shown for these cases by the diagrams at the right in Fig. 6. Table V gives, for the distributions of bearing pressure assumed in Fig. 6, the values of the bending moment at two sections of the tie and for three lengths of tie. W is the total load on the tie in pounds and the moment is expressed in pound-inches. It is seen that there is a considerable range of values of the moments, both at the middle of the tie and at the rail. It is also to be noted that a slight change in the distribution of the intensity of bearing pressure along the tie makes a relatively large change in the amount and distribution of the bending moments.

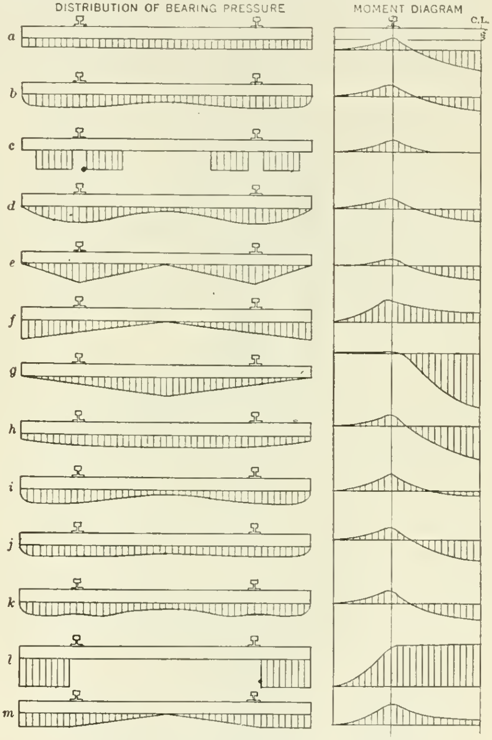


Fig. 6—Hypothetical Distribution of Bearing Pressure and Corresponding Moments for Tie 8 Ft. Long.

A study of the flexure curves of the ties tested in track and a comparison with flexure curves corresponding to the distribution of moments given in Fig. 6 show that a variety of

TABLE V—BENDING MOMENTS IN TIE FOR ASSUMED DISTRIBUTIONS OF BEARING PRESSURE.

W = Total load, in pounds, carried by one tie. Moment is then given in pound-inches.

Distribution as designated in figure.	8-Ft. Tie.		8-Ft. 6-In. Tie.		9-Ft. Tie.	
	At rail.	At middle.	At rail.	At middle.	At rail.	At middle.
a	+1.5 W	—2.7 W	+1.9 W	—2.0 W	+2.5 W	—1.2 W
b	+1.6 W	—1.7 W	+2.1 W	—1.0 W	+2.5 W	—0.5 W
c	+1.8 W	0.0 W	+1.8 W	0.0 W	+1.8 W	0.0 W
d	+1.3 W	—1.5 W	+1.8 W	—0.9 W	+2.1 W	—0.5 W
e	+0.9 W	—1.8 W	+1.2 W	—1.3 W	+1.5 W	—0.8 W
f	+2.8 W	+1.2 W	+3.6 W	+2.2 W	+4.4 W	+3.2 W
g	+0.1 W	—6.7 W	+0.3 W	—6.2 W	+0.5 W	—5.7 W
h	+1.3 W	—3.9 W	+1.6 W	—3.3 W	+2.0 W	—2.6 W
i	+2.0 W	—0.4 W	+2.7 W	+0.6 W	+3.3 W	+1.4 W
j	+1.4 W	—2.4 W	+1.9 W	—1.8 W	+2.4 W	—1.0 W
k	+1.6 W	—1.9 W	+2.1 W	—1.1 W	+2.6 W	—0.4 W
l	+4.9 W	+5.2 W	+5.7 W	+6.0 W	+6.4 W	+6.7 W
m	+2.4 W	+0.6 W	+2.1 W	+1.4 W	+3.6 W	+2.2 W

conditions of the bearing may exist. Even in well-tamped track the uniform distribution of bearing pressure indicated at (a) cannot occur. The intensity of bearing pressure will be greater near the rail than at the middle or end of the tie since the bending of the tie will result in larger depressions at that point. The more flexible the tie, the greater the variation in intensity; likewise, the stiffer the ballast, the greater the variation—all resulting in increased intensity of bearing pressure at the rail. Such a condition gives a smaller value of the bending moment at the middle of the tie than would be found for uniform bearing pressure. If the ballast at the middle of the track is less compact than elsewhere the difference becomes more pronounced. The bending moment at the rail for this condition is less than for the endbound condition. The condition given at (c) in Fig. 6 may be expected to merge into that at (d). With a concentration of pressures near the rails it may be expected that a permanent depression will soon be formed under the rail, a greater depression all along the tie will then occur upon the application of the heavy loads, and the bearing pressure will be distributed more uniformly along the tie. A permanently formed depression under the rail will increase the bending moment in the tie at the section under the rail.

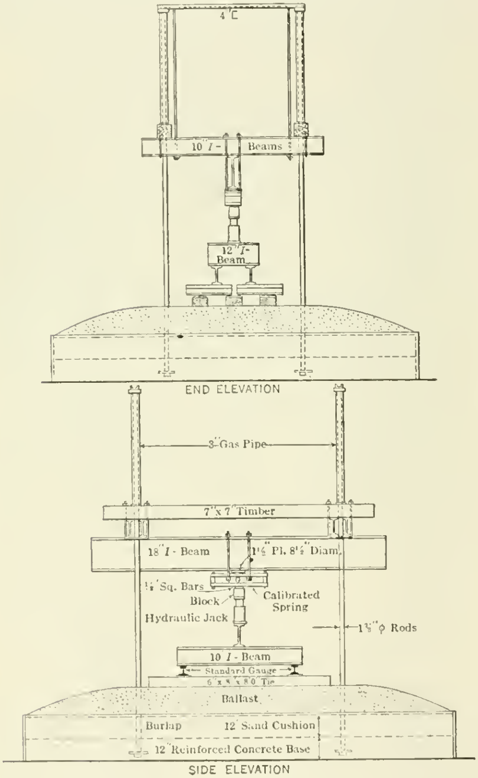


Fig. 7—Apparatus Used in Tests on Transmission of Pressure Through Ballast.

The bearing pressure under the tie of course will vary in intensity along its length. A study of the data of the tie flexure tests indicates that the maximum bearing pressure per unit of length of tie, under static loading, will not ordinarily exceed twice the average bearing pressure over the length of the tie, and that for track in good condition the maximum will be less than one and one-half times the average. These values relate to bearing pressures per unit of length of tie; as will be shown in the next chapter of the report the variation in intensity of pressure from the edge to the middle point of the width of the tie is considerable and the maximum intensity at the middle of the width may be much greater than the average.

It may be noted that the heaviest load on a tie generally occurs under the closely spaced drivers of a heavy freight locomotive, and the static load on one tie may be found approximately by dividing the weight on a driving axle by the number of ties which come within a driver spacing.

It should be noted that the present discussion relates to static loading—no allowance has been made for the effect of speed, counterweight, and impact in increasing the loads on the tie; these should be considered in finding the bending moments, stresses and bearing pressures which may develop in track service.

Transmission of Pressures in Ballast.—Crushed rock, gravel, cinders, burnt clay, slag, and sand are the materials commonly used for ballast. These materials are practically devoid of cohesion, at least when first placed. Earth and clay possess cohesive properties in some degree. Non-cohesive materials consist of separate pieces which will be hereafter referred to as grains. The grains are of irregular size and shape, and when first placed form a loose mass which cannot carry load without considerable readjustments of their relative positions. Under repeated applications of load, or other working, the grains are rearranged so that the mass becomes quite compact.

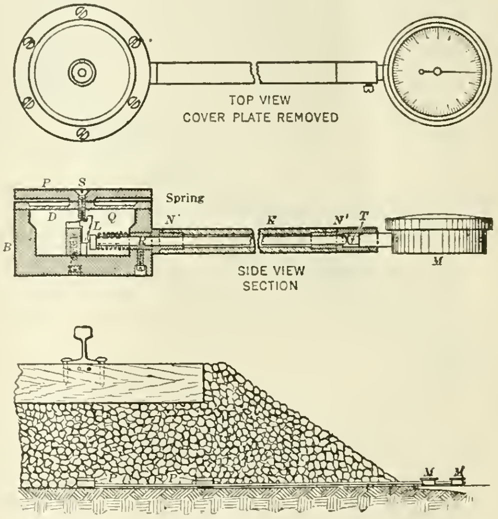


Fig. 8—Pressure Capsule and Its Place in Ballast.

By reason of its structure, a load is transmitted through a non-cohesive granular mass from grain to grain by contact pressures. The distribution of pressure is made through chains of grains in contact which lie between the load and a point in the ballast.

The Committee has made an analytical investigation of some length of a purely theoretical sort involving, first, the transmission of load through a pile of cylinders, piled as compactly as possible, and considered in three ways, frictionless, the coefficient of friction equal to or greater than 30°, and, when the coefficient of friction is between these two conditions; secondly, the case of the transmission of pressures through a pile of grains in which there are no lateral pressures.

Laboratory Experimental Work on Tranmission of Vertical Pressure.—Experimental work on the tranmission of vertical pressure through granular material was carried on for a number of years at the University of Illinois in connection with undergraduate thesis work. Although the experiments were limited to circular bearing areas and therefore are not directly applicable to railroad track, the work proved very instructive and the experience gained was helpful in planning the more elaborate experimental work afterward undertaken for the Joint Committee.

The laboratory experimental work undertaken by the Committee was made in the Laboratory of Applied Mechanics of the University of Illinois. In the attempts which had been made to measure pressures in ballast under regular track conditions, difficulties were met that showed the advisability of conducting experiments in the laboratory where conditions could be controlled and results obtained to establish some of the basic principles of the action of ballast.

Two elevations showing the arrangement of the apparatus used in making the tests are shown in Fig. 7. A reinforced concrete slab 16 by 19 ft. and 12 in. deep supported the ballast. The load was applied to the ties by means of a jack whose upward thrust was carried by I-beams to four 1⅞-in. steel rods having ends embedded in the concrete slab. The load applied by the jack was distributed to the one, two, or three ties used in the experiments by means of a system of levers. It was possible to divide the load among the ties in any manner desired. The load applied by the jack was measured by a calibrated steel spring.

For measuring the intensity of pressure transmitted to various parts of the ballast, the pressure capsule shown in Fig. 8 was used. The following description which was given in the first progress report is here repeated for the convenience of the reader:

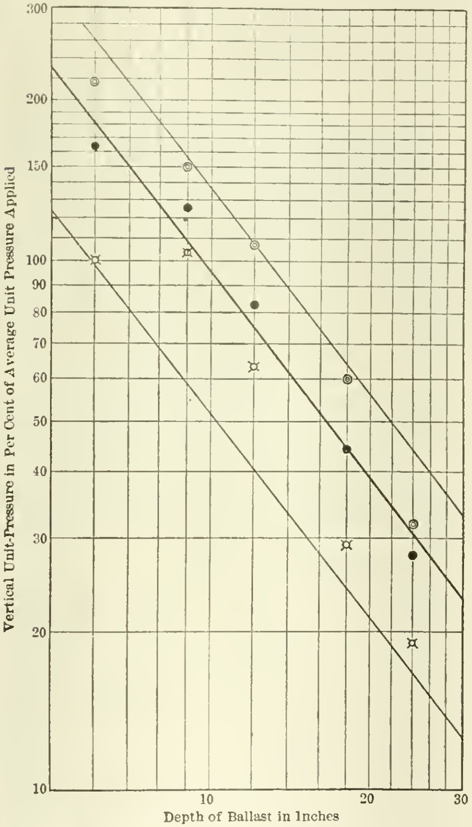


Fig. 9—Relation of Intensity of Pressure Under Center Line of Tie to Depth Below Bottom of Tie, Logarithmic Scale.

The elastic deflection of a thin steel diaphragm is used to measure the amount of pressure applied to the capsule. The pressure to be measured is received on the bearing plate P, which has an area of 5 sq. in.; the pressure is transmitted to the thin steel diaphragm D, which is fastened by screws around its circumference to the cast-iron case B. The screw S which fastens the plate P to the diaphragm D is hardened and bears on one knife edge of the small bell-crank lever L which is pivoted at Q. The vertical deflection of the center of the diaphragm is transmitted by the bell-crank lever (magnified about three times) in a horizontal direction to the rod R which slides in guides NN' and is enclosed in a horizontal tube K and finally bears against plunger T of an indicating dial micrometer, whose movement is thus a measure of the elastic deflection of the diaphragm D. If the material of the diaphragm is not stressed beyond its elastic limit the deflection of the diaphragm, and the consequent movement of the pointer of the dial micrometer, may be used to measure the load on the plate P. Sand and dirt are prevented from coming between the bearing plate P and the diaphragm by friction tape wrapped around the case of the pressure capsule. Each pressure capsule was calibrated after being taped, by placing it on a platform scale and by means of a screw clamp applying a series of loads covering the range of its use.

The thin elastic diaphragm is made of hardened steel. The bearing plate serves to take load of any distribution or concentration upon it and to apply this load as a concentrated load at the center of the diaphragm.

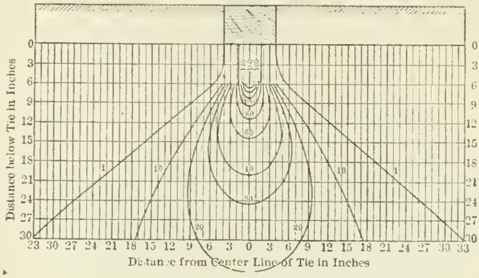


Fig. 10—Lines of Equal Vertical Pressure in Ballast for Load on a Single Tie.

There was at first some difficulty due to ballast movements causing the tube to be pulled out of the capsule. Even after making a threaded connection between the tube and capsule there was some trouble from this cause. It was finally entirely overcome by slipping a 1-in. pipe over the tube, protecting it from the pull of the ballast.

During the progress of the work some changes were made in the making of the tests. The most important changes relate to the disposition of the pressure capsules in the ballast. The locations of the capsules are shown in each case in the figures giving the results of the tests.

In the experiments with the sand ballast, the capsules were placed on the concrete slab and great care was taken in placing the sand around them in order to prevent them from being displaced. After a sufficient quantity of ballast had been placed it was struck off to a level surface at the required depth. After the ties had been placed carefully in the desired position with respect to the capsules, they were loaded five or six times before beginning to take readings. The micrometer dials were then read with no load on the ties. A small load was then applied and readings were again taken. Usually a zero load and three increasing loads were applied. Readings were taken until three consecutive sets of consistent readings were obtained. The greatest load to be applied was determined by: (a) the capacity of one or more of the pressure cap-

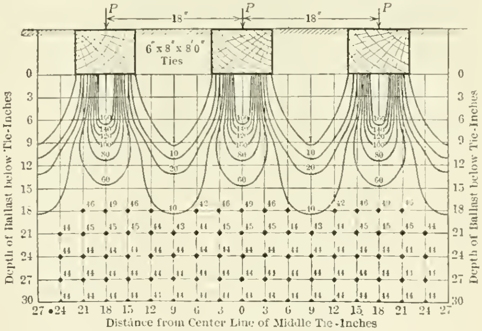


Fig. 11—Lines of Equal Vertical Pressure in Ballast for Equal Loads on Ties.

sules, (b) the carrying capacity of the ballast, or (c) the capacity of the jack.

In the first test the sand was placed so that it was 6 in. from the bottom of the tie to the top of the capsule. When the experiments with this depth of ballast had been completed the pressure capsules were rearranged and experiments were made with depths of ballast of 9, 18, and 25 in. The ballast was loosened up in each case before additional sand was put on.

Figure 9 has been drawn to express by logarithmic co-ordinates the relation between the unit-pressure at points below the center line of tie and the corresponding depth of ballast. The ordinate of a plotted point represents the pressure at a point below the center line of the tie expressed as a percentage of the average pressure over the bottom of the tie; the abscissa represents the depth of ballast at the point. The maximum and minimum observed intensities of pressure have also been plotted. A straight line whose equation is

$$p_c = \frac{16.8\ p_a}{h^{1.25}} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (25)$$

has been drawn and fits the observations fairly well within the range of the tests, although for depths less than 4 in. and more than 30 in. the results are too high. In this equation p_a is the average pressure over the tie and p_c the pressure at the given point directly below the center line of tie, both in pounds per square inch, and h is the vertical distance in inches below the bottom of the tie. It should be noted that this expression was obtained from tests with ties 8 in. wide.

Contours of Equal Vertical Unit-Pressure.—From the results of the tests it is possible to draw the contours of equal vertical unit-pressure beneath one or more loaded railroad ties. Fig. 10 shows the contours of pressure beneath a single 6 by 8-in. by 8-ft. tie. The contours are designated by percentages of the average pressure applied to the ballast by the tie. In Fig. 11 contours of equal vertical pressure are shown beneath a series of equally loaded ties. It will be noted that in general the vertical pressures become nearly constant at a depth equal to the tie spacing. It should be added that in determining the contours the principle of superposition and the laws of distribution of pressure given by the equations already derived have been useful. These laws may be applied to conditions not covered by the experimental work.

Summary of Results of Tests.—The following observations summarize some of the results of the tests and analysis and bring out in part the phenomena attending the transmission of pressure from the tie through the ballast.

The bearing pressure of the tie varies in intensity from its edge to its middle line; the maximum intensity is dependent upon the intensity of pressure developed at the edge. A variation in intensity exists also along the length of the tie.

The pressures which react from the lower face of the tie act in other than vertical lines, the greatset variation from the vertical direction being at the edge of the tie.

There is a concentration of pressure a short distance below the tie, say, at 3 to 4 in., and the intensity of pressure in the ballast at such a depth is greater than exists at the bottom of the tie.

For the tie of ordinary width the intensity of pressure at a depth of 6 in. and the distribution of vertical pressure over a horizontal plane at this depth do not differ greatly from those existing immediately under the tie. The directions of the pressures are not the same. At or below this depth the distribution of pressure laterally begins, with a consequent decrease in maximum intensity of pressure, and the change becomes more apparent as the depth increases.

The foregoing relates to the transmission of pressure from a single tie. For a number of ties with the ordinary tie spacing, the effect of the combination of pressures transmitted is readily found by superposing the values of the pressures from the several ties as obtained for a plane at the same depth. For the ordinary width of tie, the effect of the pressure transmitted from the adjacent tie to points midway between ties (overlapping lines of pressure) is noticeable at a depth equal to about half of the usual tie spacing. At a depth of three-fourths of the ordinary tie spacing the pressure immediately under the center of the tie is about one and one-half times that resulting from a uniform distribution over the horizontal plane. At a depth equal to the ordinary tie spacing the lateral distribution has become such that the variation in intensity of pressure from tie to tie is small.

The variation in intensity of pressure in the ballast lengthwise of the tie (which is dependent upon size and stiffness of tie, quality of tamping, and condition of the bed on which the tie rests) becomes less and less with increase in depth, and it may be expected that the variations will be smoothed out at a depth equal to the ordinary tie spacing, or a few inches below, where there will be a fairly uniform pressure over the horizontal plane.

The tests were made on a rigid base and the results may be expected to apply to a firm roadbed capable of carrying the loads transmitted. A depth of ballast greater than that named would be found useful when the roadbed is of uneven character or yields under the load or is subjected to unusually heavy load.

The tests show that for quiescent loading there is little difference in the manner and rate of transmission and distribution of pressure for broken stone, pebble, and sand ballasts; that is, at a given depth the intensities of pressure will be approximately the same, provided of course the ultimate carrying capacity of the ballast is not exceeded, and this conclusion may properly be extended to other non-cohesive materials. It will require less load to force the tie into sand ballast than into broken stone; the ultimate carrying capacity of the broken stone ballast under tie pressure is much greater than that of the sand ballast—the particles of sand ballast are more easily moved and rearrange themselves under lighter loads. For the different kinds of ballast there are great differences in the ultimate load which can be carried on a tie before ballast movement begins. The ultimate carrying capacity depends upon size of particle, smoothness of surface, and degree of angularity. A material whose mobility under pressure is increased by the addition of water or by mixture with other materials may thereby have its carrying capacity decreased. For heavy loading the ultimate carrying capacity of a ballast material is especially important.

It is evident that a principal function of the ballast immediately under the tie and for some distance down, aside from such functions as drainage, is to carry the load without material lateral movement of the ballast to that depth at which lateral distribution becomes effective. An advantage of the coarser, rougher kinds of ballast is that they will carry a greater ultimate load—which is of special importance in the upper part of the ballast. This is especially true under the jarring, vibrating loads of track service for which the ultimate carrying capacity naturally will be less than that found under the quiescent loads used in the tests.

The tests in the laboratory indicate, as would be expected also from analytical considerations, that the presence of ballast above the level of the bottom of the tie may have little influence on the quiescent load which will be carried before the ballast will work out from under the tie and allow it to settle, but that under repeated applications of load and particularly under jarring and vibratory loads the ultimate carrying capacity of the ballast is considerably increased by raising the level of the ballast surface to the top of the tie. This advantage is particularly apparent at the end of the tie, where under the whipping action of the tie under repeated deflections the particles of ballast will more readily be pushed away, since beyond the end of the tie there is no part of the track structure available for resisting the lateral pressure as is the case in the direction of the track, where another tie is always near at hand.

It seems probable that the effect of the jarring action of train loads will be to decrease the lateral distribution of pressure. It seems possible also that this tendency is counteracted in some degree by the cohesion which develops in ballast after it has been in place for some time.

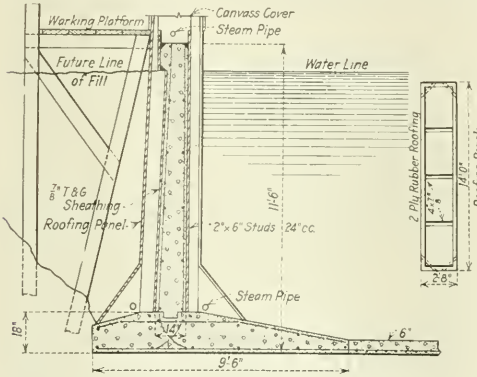
It should be added that the "lines of pressure" used in the discussion are presented as being of service as an illustrative and suggestive conception which will help to explain some of the phenomena of transmission of pressure, rather than as a rigidly scientific hypothesis.

A. A. E. Has Nearly 14,000 Members.—The membership of the American Association of Engineers was 13,668 on March 10th. During the first 11 days in March 402 applications were received.

Method of Protecting Concrete in Zero Weather Construction Operations

By using skeleton panels covered with two-ply roofing and a system of steam piping it was possible to continue concreting on a reservoir for a coal breaker in Scranton, Pa., during the zero weather of the past winter.

The reservoir is 200 ft x 100 ft. with a depth from the bottom of the foundation to the top of the wall of 11 ft. 6 in. It is divided into two compartments by a partition wall, at one end of which is located the pumphouse. The construction is the usual reinforced concrete type of retaining wall, as shown in the sketch, very heavily reinforced, with a thickness of 9 in. on top and 14 in. at bottom. The bottom of the reservoir is covered with a 6-in reinforced concrete floor. The division wall, of course, is different from the design shown to take care of the varying loading. The contract was awarded on Sept. 23, 1919, and as the excavation at that time was nearly completed under another contract, and as the total amount of concrete involved is only 825 cu. yd. the contractor figured that the work could easily be completed before the cold weather set in.



Sketch Showing Section of Retaining Wall and Method of Protecting Concrete Against Freezing.

It was found, however, when starting work that the foundation was not suitable to properly carry the reservoir, and after consultation with the owners it was decided to take off approximately 18 in. of the entire surface, install a number of French drains to take care of the accumulation of water, and dig a trench along the eastern end of the reservoir approximately 160 ft. long, 9 ft. 6 in. wide and an average of 5 ft. deep and fill it with light cinder concrete in which was embedded one-third of breaker rock, so as to obtain a proper foundation for the reservoir. This caused a delay of about four weeks, so the contractor was only able to complete about 80 per cent of the footings supporting the concrete walls, and 50 per cent of the floor of the reservoir, as well as about 200 ft. of forms for concrete walls, when the cold weather set in and stopped the work. Owing to the severity of the winter the most economical way would have been to close the work down entirely, but as the coal company were very anxious to have the reservoir completed at the earliest possible date in the spring it was decided to protect the concrete from freezing in some way in order to keep the work going as much as possible.

Canvas covering was only obtainable at a prohibitive figure, and besides did not look to be very practicable for protecting 100-ft. sections of wall, which was to be poured at one time. Wood sheathing also proved expensive, particularly since it would have had to be taken off every time the forms were moved. The contractor therefore built skeleton panels of 4-in. x ⅞-in. boards, properly braced and covered them with two-ply rubber roofing, which was held in place by wood lath. These panels were lightly fastened to the outside of the studs of the form work, which was done in the usual manner, being held in place by wires. The bottom panel was flared out at an angle of about 45 degrees, and a steam pipe was installed on each side of the wall and for its full length. When concrete was poured to the top narrow canvas strips and cement bags were used to cover the top of the forms, after an additional steam pipe had been installed on the top of the wall. This afforded a complete circulation of warm air around the outside of the walls, and it protected the work perfectly even though the thermometer went down to 10° below zero in some nights.

The cost of material and labor for making the panels for about 125 ft. of wall was $300; the cost of placing and removing them is very slight. The panels can be used over and over again and also come in handy for protecting stone, sand and brick against snow and rain.

The usual method of heating the stone, sand and water used in the concrete with steam was employed, and in addition a Hauck kerosene concrete heater was used when it became necessary.

The contractor for the reservoir was Ludwig T. Stipp, Scranton, Pa.

Defects in Screw Spike Installations

The Committee on Ties, in a report submitted this week to the annual convention of the American Railway Engineering Association, presents some matters of interest concerning the use and abuse of screw spikes and gives the results of extended observations on various screw spike installations.

The committee endeavored to study especially the effect of the screw spike on the durability of the tie, feeling that the further use of screw spikes depends largely on this effect and how long the holding power of the wood around the screw spike can be maintained relative to the life of the tie. In the investigation the committee has gone over some 230 miles of screw spike installation, stopping at frequent intervals to make detail inspections of the ties and fastenings. They have found varying conditions of installations and results. Some screw spike installations, made in 1908 in good treated ties, were found to be still in thoroughly good condition and capable of many more years' life. Some other installations, made at various times since, have not been so effective. The defects found which seem to the committee to cause over-strain of the wooden threads of the tie which holds the screw spike, may be described as follows:

Improper Design of Fastenings.—The threads in the wood were found injured where the screw spike did not have an accurate and uniform pitch and diameter of core. Where that condition existed the first installation of the spike injured a portion of the fiber, and where the screw spike had been changed, in connection with replacing a rail or tie plate, further damage was done. The wood fibers at the top of the hole in the tie were found destroyed where the screw spike used had no pilot or small point on the end to permit its being screwed into place after being set in with a light tap of the hammer; that is, the holding power of the timber was destroyed for whatever distance the spike had to be driven in the hole, so that the lighter the tap required to set the screw spike ready for being turned, the less of the fiber of the tie was injured.

Distortion of the fiber of the wood was found where the head of the screw spike rested directly on the top of the base of the rail, this damage apparently depending on how much wave movement there was in the rail as the train passed over it.

Spikes were found forced out of position, so as to injure the timber, where the following conditions existed:

(1) Where the tie plates were not of sufficient size and thickness, so that they buckled or cut into the tie.

(2) Where there was no shoulder tie plate used, so that the spikes were placed against the outside edge of the base of rail and acted directly to hold the gage.

(3) Where there was no support or bearing for the head of the screw spike so designed as to hold the screw spike a prescribed distance above the base of the rail and provide a freeway for the movements of rail without stressing the holding power of the spike.

(4) Where the holes in the tie plates, through which the screw spikes were placed, were unnecessarily larger in diameter than the screw spike. This resulted in an inaccurate in-

stallation, so that the holding power of all the screw spikes was not effective at the same time.

Improper Kind of Wood in Ties.—Some soft wood ties were found which were not strong enough to hold the thread under the stress produced by the heavy traffic and axle loads carried.

Improper Method of Installation.—The most common cause of destruction of the threads in the tie was found to be due to the screw spike having been partly driven with a hammer in starting. The committee saw screw spikes being hammer driven for a distance of one-fourth to one-third of the length of the threaded portion. This practice results in destruction of one-fourth to one-third of the holding power and enlargement of the top of the hole, which permits water to accumulate, the further destruction of the wooden threads, as well as corrosion of the spike.

Decay was found in ties where spike holes were bored after the tie was treated and no preservative put in the holes before applying the spike. Where the hole in the tie had not been bored deep enough to permit setting spikes down as the tie plate embeds itself, the wood threads were stripped in an attempt to tighten the spike. A quite general condition of bent and partly pulled screw spikes was found at rail joints, due to creeping rail, the spikes being placed, as is usual, in slots in the joints; this resulted in the destruction of the wooden threads of the tie. In a few cases the wooden threads were found stripped where the spike had been turned too many times with a power machine.

Standard of Maintenance. The condition of line, surface and the stability of the roadbed were found to have an important effect on the holding power of the spike, the over-straining apparently beginning when there was more movement of the rail on the tie than freeway space could be allowed for.

From the varying methods and results seen, the committee has stated the conditions it believes necessary for the protection of the tie in connection with a screw spike installation. The following is recommended:

(1) The timber of the tie should be adequate in strength for the tonnage and maximum axle loads carried. For heavy traffic the following is considered preferable: Hardwoods—such as white oak, various species of red oak, gum, beech, maple, birch and dense grade needle leaf woods; it being understood that the woods herein mentioned belonging to the treatment class must, under all circumstances, be treated.

(2) The ties should be bored and adzed, and where the timber used is to be treated, that treatment should be applied after the boring and adzing is done.

(3) The holes for the screw spikes should be bored completely through the ties, except that special consideration should be given this question where there is a heavy electric current in the track rail which might become grounded by this means. These holes should have the same diameter as the shank of the screw spike.

(4) A shoulder tie plate should be used of proper design, correct dimensions, width, length and thickness, to properly protect the tie, so designed that the spike does not in itself maintain gage, but holds the plate securely to the tie, thereby enabling the shoulder to maintain a proper track gage without a spike-rail base contact, reducing to a minimum spike cutting and mechanical tie destruction. Additional shoulders should be provided on which the spike head will bear, or rest, when the spike is screwed in tight. These shoulders should be so made that the plate will be held securely to the tie end and, at the same time, a given freeway will be provided between the spike head and the rail base, sufficient to take care of the rail deflection due to loading and track surface conditions. This freeway will vary with the character of the subgrade maintained and weight of rail, but one-eighth of an inch is recommended as good practice for 100-lb rail with average high speed condition. This may be decreased to 1/16 in. on track where a so-called permanent form of construction is used and the speed is low, or raised to 3 16 in. where the flexibility of the track is greater.

(5) When the screw spikes are placed in slots of the angle bars care must be taken to see there is not an undue stress on the screw spikes from creeping rail. The rail should be anchored so as to prevent its running on the ties, to permit the full use and value of the screw spike when the spikes are placed in the slots of the angle bars. If the rail has to be allowed to run freely, due to its location on bridge decks or trestles, or for some other reason, screw spikes should be kept from the slots of the angle bars, so that the rail can move freely.

(6) The screw spike should have an exactly uniform pitch and size of core. The diameter of the lower part of the screw spike should be decreased so that the beginning of the thread is slightly less than the diameter of the hole bored in the tie. It is considered essential that the spike be screwed in the wood without the fiber of the wood being destroyed. In order to accomplish this, the spike must be started with a very light tap—just sufficient to get holding power in the threads to permit its being turned in the tie. For this purpose the use of the screw spike adopted by the association is considered essential. The present injurious practice of starting by driving the spike should be discontinued.

Suggested Practice.—The following is suggested as good practice to get economic results:

(1) At least four holes should be bored in each plate bearing area even if only two screw spikes are used at each rail. This is an advantage in helping quick repair in case of damage to track. It would also have some effect in treatment by allowing the preservative to get where it is of the greatest value.

(2) The materials used for connecting the rail to the tie should be of such character and strength as to equal the expected life of the tie. The renewal or changing of these fastenings has a tendency to weaken the tie, and the cost of making these renewals should justify a reasonable expense to make these materials of full strength and to protect them against corrosion.

(3) It is believed that the full benefit of a screw spike installation cannot be obtained unless the standard of maintenance of line and surface is fairly high as compared with the tonnage and character of traffic passing over the track; that the roadbed should have good drainage, ballast, well tamped track, fair line and surface, and a foundation which is not too yielding.

Conclusion of Committee.—It is the opinion of the committee that screw spike installations should be made in conformity with the above recommended practice in order to properly protect the tie. It is difficult to accurately measure the damage done to a tie by a screw spike until some of the modern installations have been in longer, so that a definite and economic statement can be made from the records. Each year adds to the information available, but it is probable that conclusive figures will not be made until the life of the present modern installations can be determined.

It is believed that these installations should be watched carefully, because as the railroads get longer life from their ties by preserving them, there is more chance of spike killing being a limiting factor.

How a Construction Equipment Manufacturer Follows Up Prospects

Endeavoring to give contractors real facts about the performance of its concrete mixers in terms that contractors most appreciate, the Chain Belt Co., Milwaukee, Wis., has adopted a novel and interesting method of following up prospects. Through its representatives in distributing centers in the country, the company is sending out a series of performance stories, each bulletin carrying a separate story about some particular mixer or contractor. Each pamphlet tells the story of actual performance, frequently in figures, in a most unique manner.

The bulletins are gotten up in conformity with the company's advertising page treatment with a strand of chain, symbolic of the type of concrete mixer, running down the edge of the page. In addition, an illustration of the particular machine in question is shown across the top of the bulletin.

It is the purpose of these bulletins to bring to light facts and features about the machines as seen by the users. The stories are compiled from facts submitted by contractors, each telling of his own experience.

The method of distribution is also well arranged. At regular intervals the prospect receives a performance bulletin telling him this week about some contractor out in Salt Lake City, next week about some machine at Atlanta, Ga., and another about some particular job at Schenectady, N. Y., and so on.

SCIENCE OF MANAGEMENT

Application in Civil Engineering and Construction Fields

The term Science of Management was coined by the editor of Engineering and Contracting and first used in "Cost Analysis Engineering" (1908) and explained more fully in "Cost Keeping and Management Engineering" (1909). The last named book, which contains ten laws of management and many subsidiary principles, was the first book on the science of management. In the columns of this journal many additional laws, principles and detail methods of management have been published. This section, which appears weekly, may be regarded as a serial sequel to the two books above named.

Piece Work System of Payment for Underground Work in Mining

Practically all underground work on the Minnesota iron ranges is done by miners working on a so-called contract wage system. As usually practised this involves the setting of a price per foot in development work, or per foot or per car, usually the latter, in slicing or stoping, by the mining captain. A price is set for each working place, in which there are usually two men per shift. This price includes labor and supplies, such as explosives, fuse and caps, shovels, carbide, etc., and the men divide the total earnings less the amount expended for supplies. The cost of the supplies charged to the men varies in different mines; in some cases supplies are furnished free. In general, the companies furnish machine drills, hose, steel, picks, rails, cars, timbers, boards, lagging, perform some of the transportation and all of the hoisting, and may do some of the track work. The miners do all of the shoveling, drilling, blasting, timbering, etc., and some of the transportation. Supplies chargeable to the men are usually furnished at cost, plus 10 per cent for handling.

In general the rate per foot or per car, or the contract price, is set at the first of each month and governs the month. Earnings are frequently calculated and checked by the mining captain, and many companies also figure the rates on the 15th of each month. Some of the contracts will show large earnings, others average earnings, and others small earnings. When the earnings are small, the rate has been insufficient, in which case it is raised, and a new rate governs the remainder of the month; or the contract has encountered unusual and unexpected difficulties, in which case the contract may be closed and the men paid off at the company-account rate and a new contract started, or they are allowed footage or cars not actually earned; or the men are poor workers or unskilled miners, in which case they are paid off at the company-account rate and discharged, new men are hired, and a new contract started.

This system, while it has certain advantages over the straight day's pay or company-account method of wage payment, has serious defects. The difficulties of the system arise from: The setting of the price, often under protest from the men, by one individual, the mining captain; the difficulty in foreseeing conditions underground 30 days in advance and the multiplicity of operations entering into the contract price make the off-hand setting of the price by the captain a mere guessing matter; rate cutting, after a rate has been set, and earnings have been found to be abnormally high.

In a paper presented last month before the American Institute of Mining and Metallurgical Engineers by Mr. A. K. Knickerbocker of Cygune, Minn., various interesting suggestions for improvements in the contract system were made. The matter following is extracted from Mr. Knickerbocker's paper.

Time Studies Basis of System.—The keynote of the improved plan is standardization, based upon accurate and sympathetically carried out time studies. No piece-work wage payments can be made satisfactorily unless each operation is standardized and the time and cost of doing it are definitely known. In other words, we must have, instead of rates set upon individual autocratic judgment, rates set scientifically and based upon long-continued and accurate time studies.

The business of mining iron ore is not simple, and to handle the matter we will have to divide it into simple operations capable of definite time and cost ascertainment, and classify these operations into two classes—fixed operations and variable operations. The fixed operations are: Shoveling, drilling and blasting, tramming, timbering, boarding up and blasting down rooms, tracklaying. These are all fixed determinable factors that, by means of accurate and long-continued time studies, based upon the work of average miners, would give an easy determination of the proper pay. These time investigations would prove, for instance, that the average miner can shovel a certain size of car of ore for X ct., which amount should then be the price paid for this work all through the mine, until such time as the general level of wages is changed.

Likewise with drilling and blasting; although experience would point the way as to the proper method of handling this question. Whether this work should be paid for at so much per foot or per car or ton, or per foot of hole drilled, is a matter that could be worked out at the proper time. This item is also a semi-variable, in that the several kinds of ground must be considered. To handle this successfully, the number of kinds must be kept at a minimum. Five grades are suggested, very soft, soft, medium, hard, and very hard. This is the only item where the judgment of the mining captain is brought into play, or the only chance there is for any disagreement or argument between the men and the captain. Surely the captain should be able to classify any face into one or the other of these five grades, especially as the grades will have been well delineated by the preliminary time study and investigation work. The system should be worked so that the rate on this item can be changed during the month as often and as quickly as the ground changes from one class to the other.

Similarly, tramming should be paid for at so many cents per various sized cars trammed 100 ft. or fraction thereof. Timbering would be paid for at so many cents per set, based on a certain length post and cap. The rate would raise or lower with a change in the post or cap length, or both, above or below the base lengths. Boarding up rooms would be paid for at so many cents per square foot or hundred square feet boarded, and blasting down of rooms would be paid for per 100 or 1,000 cu. ft. of room blasted down. Tracklaying would be paid for at so many cents per linear foot for straight track, so many cents per foot for curved track, a lump sum for switches, frogs, tracks into slices, etc. Since in most mines a good share of the track work is done by a special track man this item would not be very important.

The variables entering into the problem are, unhappily, numerous, but the crux of the whole problem lies in the treatment of these variables. The variables include all those items that cause a loss of time to the miner and prevent him from using his time in one or the other of the above six fixed operations. These delays should be classified into two well-defined classes: those for which the miner is responsible and which would have been avoided by ordinary mining skill or foresight on his part, and those that are in no way under his control and are due to neglect of the company or accidents due to the nature of the work, such as unforeseen caves or falls of ground. For the first class, the miner should receive no pay. For the second, he should automatically go upon company-account pay the minute that he starts to suffer delay and be paid for all the time he is so delayed. This company-account rate should be made low so that advantage will not be taken of it, and also because there is presumably little or no expenditure of effort in most of the cases coming under this classification.

The Contract Sheet.—The contract sheet at the end of the month would then look something like this:

To shoveling A cars, A size, at a cents per car............ ......
To tramming A cars, A size, 300 ft., at b cents per car per 100 ft. ....
To drilling and blasting, soft ground, at d cents per car (or foot of drift).. ......

To timbering, E sets, 7-ft. post, 6-ft. cap, at e cents per set	......
To boarding up rooms, F sq. ft. at f cents per 1,000 sq. ft.	......
To blasting down rooms, G cu. ft. at g cents per 1,000 cu. ft.	......
To H hours delay, waiting for full chute, at x cents per hour	......
To I hours delay, blasted down sets, no pay.	
To J hours delay, no air, at x cents per hour	......
To putting in K props, at k cents per prop	......

Supplies could be handled in the usual way and figured in the standard rates, or supply standards could be adopted, supplies furnished free, and savings made by efficiency on the part of the men divided between the company and the men, on an equitable basis.

The plan as outlined is still a straight piece-work system. Whether it would be advisable to develop a standard day's work and standard day's pay and encourage efficiency by the installation of some sort of bonus payments is a matter that would develop as the system was worked out and put into practice. The introduction of bonus payments would be a complication to avoid until such time as the improved piece-work method has received a good trial, become stabilized, and found favor. It is believed, however, that an attendance bonus, or the granting of a shift or half-shift per month for full or nearly full attendance during the month, would help to keep the working force full each day and is an application of the bonus system that might be instituted immediately upon the adoption of the improved piece-work system.

A little more clerical work would permit of the calculation of the earnings of each contract each day, with a daily posting of earnings in the change house, where they could be observed by the men. As a stimulation to a man to put forth increased efforts, there is nothing like an idea of what his present efforts are actually bringing him and an immediate knowledge of his earnings each day. Whether such a step is advisable or will pay for itself is open to experiment after the system is in proper working order.

Disadvantages of Suggested System.—The disadvantages of the suggested system are, of course, items of cost, due to the extra supervision and time keeping entailed and the necessity for frequent check-ups by the management. In a small mine, the details could be looked after by the shift boss but a mine of any size would require men doing nothing else but checking time, etc., and looking after the operation of the system. It is believed that the extra labor would earn its money, as the operation of the system would be, in effect, a continuation of the preliminary time and cost studies, and it is felt that the system would present facts of operation in such a manner as to quickly uncover the weak spots of an operation and suggest means for the application of suitable remedies. For instance, the daily records would show that some gangs were above the average in certain lines of work and below the average in others; steps could then be taken to discover the gang's difficulties and by education improve the production and earnings of the gang and lessen the cost to the company. Certainly it would mean a detailed and accurate cost system applied where it should be applied, to the man actually producing the ore, and it is inconceivable that the system would not furnish to the captains and superintendents a ready and up-to-date means of detecting weak spots in their operations and determining quickly and accurately the means of correcting them, and thus lead to a general reduction of costs to the limits toward which all are striving.

Another disadvantage is that the system could not be put into operation without some initial and preliminary time studies and investigations performed on average men and under widely varying, though typical, conditions, and under supervision of men sympathetic to improvements. The longer this work is continued prior to the adoption of the system, the more accurate and fool-proof it will be. These investigations can best be made by the large companies, having various mines and with large organizations equipped for the work. The cost would be prohibitive to a small company. This preliminary investigation would no doubt take two or three years' time and cost some thousands of dollars, but the savings made on the millions of tons of ore mined and shipped each year would repay the cost many times over, due to the knowledge obtained even should the work stop with the preliminary investigations.

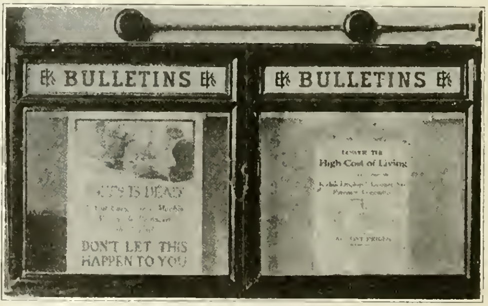
Advantages of Suggested System.—The advantages are numerous and have previously been indicated, but for convenience will be here summarized briefly: (1) Prevention of disputes; the basic rates for each operation would be standard throughout the district. (2) Less dissatisfaction among the men. (3) Less opportunity for the strike agitator. (4) Better work by the men, due to the fact that they would see that unfairness and injustice had been abolished and would feel that they were getting paid fairly for work performed. (5) A smaller labor turnover. (6) A reduction of operating costs to the companies. (7) Opportunity for increasing the efficiency of the men and the improvement of operating conditions and methods, due to detailed costs presented quickly and knowledge obtained from them.

The suggested system may not be the best, and it is not expected that any fair system can be derived without actual study and experimental trial, but in the interests of both the men and their employers, some steps should be taken to improve the present system.

Intersperse Safety Instruction With Plant News on Bulletin Boards

Bulletin boards in two sections, with removable backs, have produced good results in the plants of the Eastman Kodak Company, according to National Safety News.

One-half of the board is devoted as far as possible to bulletins on safety, health, Americanization, thrift, and similar subjects of an educational nature. These bulletins are changed daily and varied in character so as to be as attractive as possible. In some cases it has been impossible to furnish complete sets of bulletins for all boards at one time, and the plan has been used of rotating the movable cardboard backs from board to board.



Two Section Bulletin Board.

The other half of the board is devoted to news items relating to the plant or to the company. These may be changed daily but usually are posted during three or four days. The board, here illustrated, contains on the righthand side a typical notice of this sort, describing a plan for reducing the H. C. L. by co-operative purchasing committees.

Considerable time and attention were given to placing each board where its messages would reach the maximum number of people when their minds are receptive. There is an average of approximately one bulletin board per 100 employes, although in one plant there is one board for every 50 employes. Each board is illuminated by four 25-watt lamps.

A Glossary of the Mining and Mineral Industry.—A mining glossary that is much larger and more comprehensive than anyone heretofore published has been prepared by Albert H. Fay, mining engineer, Bureau of Mines, Department of the Interior, Washington, D. C., and published by the bureau as Bulletin 95. It contains over 20,000 terms and nearly 30,000 definitions, covering both technical and local usage in various branches of the mining and mineral industry, as coal mines and coke-ovens; metal mines and metallurgical works; quarries; oil and gas wells; geology, mineralogy, etc. It also includes over 2000 Latin-American mining terms. Many obsolete terms are defined. This publication may be obtained through the superintendent of documents, Government Printing Office, Washington, D. C., for the actual cost price of 75 ct.

Suggestions for Practical Training of the Railway Engineer

As an appendix to the report of the Committee on Economics of Railway Labor, presented this week at the annual convention of the American Railway Engineering Association, a sub-committee submitted the following suggestions on training engineering employes:

Advisory Control of Subordinate Engineers.—Generally speaking, the newly-graduated engineer is a mathematician and the problem is to make him also an economist. This is usually a slow and exacting process. We feel it to be true that, on most railroads, the training and educating of Engineers is unmethodical. This situation is probably natural enough as the demands of the service have required concentration of attention and effort from the responsible officers on the work in hand, giving but little opportunity to the development of the idea of advisory control of subordinates. The result has been that the development of the individual is almost wholly that which comes from his being thrown upon his own resources.

Where work is not well done fault may be found, but it must be borne in mind that, besides errors of commission, the man whose training has not been rounded out can be charged with many errors of omission. The error of omission, the failure to avail oneself of opportunity, is less likely to be brought to notice, and, without corrective guidance, the young engineer, who errs in this direction, is likely to stagnate. Here, then, lies the great opportunity for development of men. Division engineers, being charged with the duty of maintenance, under whose immediate direction are brought most of the young engineers on a railroad, must be impressed with the importance of developing their men and broadening their touch with all questions of engineering. It is, however, the opinion of the committee that even the division engineer, who is the mentor of the young engineer, does not, as a rule, direct his own attention to the question of economics as fully as should be the case in a position of that sort. Sometimes this is chargeable to the engineer and to his temperamental deficiences, but, generally speaking, especially on the larger systems, the engineer's sense of the importance and proper value of statistical information with respect to the economical performance of work under his direction is dwarfed. This is largely because of the length of time that elapses between the completion of a particular job and the time when data as to the cost of the work is available. The stores department charges out the material and the auditing department compiles the accounting.

You Can't Make an Economist by Admonitions Alone.—The engineer must get under the load and be brought to a realization of responsibility for consequences, but this cannot be done unless the man in charge is placed in a position where not only will he direct labor in the application of material, but he will be in first-handed touch with all of the elements of cost as the work is in progress. Certainly the cumbersome system of accounting with respect to maintenance of way expenses, and such construction of minor character as is usually delegated to a division engineer, does not make for efficiency. It is hopeless to attempt to make an economist by admonition alone. To tell a man about the cost of a job six weeks or more after it is completed will not help at all so far as that particular work is concerned.

The foregoing appears like a criticism of railroad methods rather than consideration of the subject-matter, but it is an important part of the machinery of economics. There should be at the command of the engineer such control of materials and primary accounting that he may at all times check up, in a thoroughgoing manner, the work under his direction and be made responsible for the economical performance of it.

Program of Development for Educating Young Engineer.—In addition to having a system by which men in charge of work may readily ascertain costs when they are incurred, it is the opinion of the committee that, on roads where the size of the engineering forces will warrant, there should be attached to the department a man well equipped with practical experience and technical training who would be fitted to conduct a program of development. Such a man would collect statistics, make an analysis of work accomplished and direct a campaign involving regular meetings composed of the members of the engineering force from the various divisions as well as from the general office. Papers would be prepared on subjects assigned to individuals and reports made on matters referred to committees whose membership should include beginners as well as those advanced to higher positions in the service. At such meetings, constructive criticism should be advanced as to work subject to comment, either as to methods of prosecution or economy.

The exchange of views would be beneficial to the service and educational to the men. It is hopeless for any official in charge of various projects, the completion of which continually demands his attention, to expect to singly accomplish much in educating the young engineer, even though every opportunity is seized as incidents occur. Such incidents are usually examples of errors of commission, and what is needed is to educate men to think in a broad way.

When we speak of economy it must not be summed up in the idea of parsimony. The most important economies sometimes require the greatest outlays. The interest of engineering organizations will be served best by developing men to think wisely in large matters as well as in small.

Importance of Proper Gaging of Productive Effort.—In the training of young engineers the essential feature is to teach them to properly gage productive effort. Probably one of the best methods is to establish a system by which a certain percentage of the positions of supervisor may be filled from the engineer corps. This system affords the engineer an intimate detailed knowledge of the methods of applying material; it enables him to fairly gage the reasonable product of labor, and brings him in direct contact with the foremen and the men, a feature which, when he has been promoted to division engineer or some higher position, is of immense advantage to him. Not only will he personally know many of his employes, but his experience as supervisor will better enable him to get the viewpoint of the men and increase his usefulness as administrator because of his ability to maintain relations understandingly with the rank and file. He will, by his training, be enabled to direct working forces, to properly proportion gangs to the work, and to pass fair judgment on the efficient performance of the men under him. One of the requirements for appointment to the position of division engineer, or engineer maintenance of way, should be at least two years' experience as supervisor.

Service in Office of Chief Engineer Desirable.—Another step in the education of the young engineer should be a requirement that he have not less than one year's service in the office of the chief engineer. This will impress upon him the theories which have been acquired at school and give opportunity for applying them in practice. Service in such capacity, he will learn more thoroughly to appreciate some of the nicieties of engineering and the necessity and proper manner of furnishing information and of carrying out the details of work which later on in his career he will be called upon to do. It is a fact to be deplored that there is a great lack of designing ability among maintenance engineers, that is to say, from the division engineer down. Too much attention is paid to the tamping of ties and the construction of sidetracks to the exclusion of the fundamentals of engineering design. Service in the general office will in a measure cure this condition, which is a shortcoming not because of faulty education but because of lack of opportunity to apply in practice the things learned at school.

To summarize as to engineering forces, the committee suggests:

(1) Employ in the engineering corps men of sufficient technical training to be useful in solving the ordinary engineering problems.

(2) Carry on an educational campaign through regular and periodical meetings, the members to exchange views through the media of papers, reports and discussion.

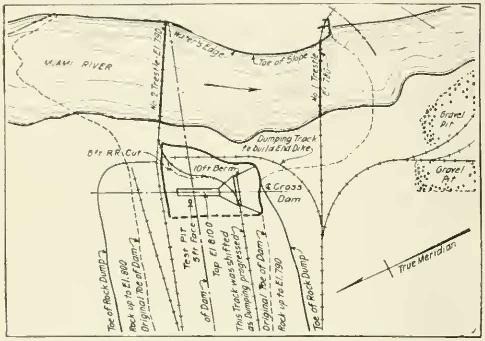
(3) Fill a certain percentage of the positions of supervisor of track, supervisor of bridges and buildings, supervisor of signals and inspector from the engineering corps on an equal footing with other applicants.

(4) Systematic rotation of service for the members of the engineering corps, to include surveying and field work, inspection, supervision of maintenance and construction and work in drafting and designing.

"Plastic Fill" Method of Embankment Construction

In building the section of the Taylorsville dam of the Miami Conservancy District it was necessary to construct a crossdike to enclose one end of the core pool. This cross dam was built by the "plastic fill" process—a method apparently hitherto little used. An interesting description of this method is given in the February Miami Conservancy Bulletin from which the matter following is taken.

The cross dam was originally planned to be built by the rolled fill process, and at the start that process was indeed used, the lowermost portion, 2 to 5 ft. in thickness, and amounting to about 11,000 cu. yd., being spread, wetted and rolled in 6-in. layers in the regular manner. The work was begun Aug. 5, 1918, but by Sept. 11 the engineers in charge made the change to the new method, the cost for the rolled embankment, following the upward trend of all prices, having been around $1 per cubic yard. It was believed that the new method would give not only a solid and impermeable structure at less expense, but would result in a material speeding up of the work, wet weather, which completely stops rolled fill, having caused a great deal of annoying delay. The placing of the plastic fill, by adjusting the quantity of water injected into the material, can be carried on rain or shine.



Layout for Building Cross Dam.

The new method was suggested by Mr. G. L. Albert, Superintendent of the work of hydraulic fill, he having successfully employed it on the Catawba dam, near Bridgewater, N. C., for settling dumped dry fill, and also for the same purpose, in building canal banks for mining operations in California.

The layout, shown in the sketch, in its main features was the same as that for the rolled fill. The material was dug from a borrow pit on the east bank of the river by a small Type 36 Marion steam shovel, loaded into 12-yd. dump cars, transported across the stream on the down stream trestle by a 40-ton locomotive, and for the rolled fill unloaded by a dragline excavator into a hopper, whence it was conveyed in dump wagons to the point where it was to be spread and rolled, the track being along the east edge of the cross dam. To adapt this outfit to the plastic fill it was only necessary to remove the hopper, dump wagons and steam roller.

The substitute equipment was very simple. It consisted only of a small duplex steam pump drawing water from the river, and a 5-ft. and a 10-ft. length of ¾-in. gas pipe to take the place of the nozzle used in wetting down the rolled fill. Later the steam pump was dispensed with, water being obtained from the high pressure monitor line of the hydraulic fill equipment.

The operation also was simple. The material was dumped by the trains on the ground beside the unloading track. It was picked up by the dragline bucket and dropped in a windrow along the west side of the cross-dam site, but well within the west limit of it. This windrow was built up dry to a center depth of about 10 ft. One of the 10-ft. lengths of gas pipe was then connected by a hose to the steam pump and used in the manner of the needle of a hypodermic syringe, the nozzle piercing vertically to the bottom of the windrow, through a row of holes about 2 ft. west of the top of the material, and about 3 ft. apart. The water was thus introduced, by injection and percolation, throughout the west half of the mass, from the bottom to the top.

The effect was interesting. The material was dropped into the windrow, dry. The water introduced by the "hypodermic" made it plastic, and it began to flow slowly, like molten lava from a volcano, under the pressure of its own weight. The windrow being wet under its west slope, the flow was naturally in the direction of least resistance—west. This had been foreseen, and was part of the program. The west limit of the cross dam was out of reach of the dragline, from its necessary position in reach of the material dumped by the trains beside the track. By dropping continually fresh material on the top of the windrow—thus loading the top—the stiff dough in the west slope was kept in motion, very slowly, till it reached the limit staked out for it—the west limit of the cross dam. It thus transported itself, under the pressure of its own weight, a maximum distance of over 40 ft. If it showed signs of "weariness," and began to slow up too much, a fresh injection of the "hypodermic" spur or a fresh load of earth on top, started it again. The motion was always, of course, exceedingly slow—glacial in fact, or as has been said, like lava 3 or 4 ft. or less, per day, and for practical purposes under control.

It should be understood that the procedure referred to was followed only on the west 40 ft. of the cross dam. The remainder of the site, being in reach of the dragline bucket, permitted a simpler process and one requiring less careful watching. The general method was to build the cross dam up in 10-ft. horizontal layers, the dragline traveling down the approximate longitudinal center line of the cross dam, on the layer just completed, and depositing the new layer behind it as it went. The growing edge of the new layer thus sloped toward the machine, the fresh material being deposited on this slope, and each bucketful jetted as it was dropped. A flow of the fresh material was maintained by this means, of the nature already described, toward the dragline, the speed being a rough measure of the plasticity, and therefore of the water in the material. The flow was controlled in the manner already indicated, and could be completely stopped at any time by dropping a windrow of dry earth at the foot of the creeping slope, a procedure which at the same time corrected the excess water by gradually absorbing it.

It was excellent proof of the solidity of the embankment secured, that the dragline—a Class 14 Bucyrus steam machine with 70 ft. boom and 2-yd. bucket, and a working weight as given by the makers of 62½ tons—rode upon the structure without causing undue settlement. There was practically no time lost in grabbing for material which might try to creep from under and escape at the edges.

The strip of the cross dam referred to, 40 ft. in width, lying out of reach of the dragline, was built up in layers like the rest, these layers all lying on about a 4-to-1 slope, the material in each layer being made to flow down this slope in the manner already described. The flow in each case was brought to rest at such a point that the west slope of the finished dam, although somewhat irregular, stood approximately on a 2-to-1 slope.

The total material in the cross dam is 45,330 cu. yd., of which about 35,000 was deposited by the plastic method. The total height is 42 ft. The hydraulic fill began on Oct. 17, 1918, about a month after the beginning of the plastic fill. The cross dam was kept at a minimum of about 10 ft. above the pool level, the maximum being about 25 ft. There was a little sliding into the pool from the cross dam material where the latter was carried across the center line (cut-off) trench, but not enough to cause any trouble. The work on the cross dam was stopped during freezing weather, in the winter of 1918-19, but the mildness of the season was such that the delay from this cause was not great.

As to reliability, two tests were made during the progress of the work which proved very satisfactory. A test pit was dug to a depth of about 5 ft. The walls of this pit stood vertical without sign of flow or break, the material damp, solid, and in texture like the cut surface of a cake of putty. At another time a railway cut, necessary for handling trains of rock fill across the damsite, was excavated in the cross dam. The west wall of this cut stood 8 ft. high, on about a ½-to-1 slope, the exposed material resembling in dampness, texture and solidity the walls of the test pit, and like them without sign of flow or break.

A final word needs to be said about the material. This was largely made up of glacial fill from the east river bank, containing a large percentage of clay, the whole giving a mixture which would permit the water to escape. The point needs emphasis. Too fine and retentive a clay, which hangs onto its entrained water, would no doubt give trouble if used for plastic fill. This was in fact discovered at the Englewood dam, where rolled fill proved to be best. The new process, like any other, has its limitations. Where conditions permit, it should have a considerable and perhaps a wide application. Of its value at Taylorsville there can be no question.

General Principles for Securing Relief from Pre-War Contracts

Suggestions of interest to contractors who suffered losses from pre-war contracts were given by Mr. Earl R. Ferguson, Shenandoah, Ia., in an address presented Dec. 30 at the annual meeting of the Levee and Drainage Contractors' Association. The address follows, practically in full:

Principles in Standard Text Books.—First of all the general principles upon which the theory of your possible defenses probably exist are found in all of the great standard text books, found upon the shelves of all lawyers in every state. I refer to old standard works like Page on Contracts, the Encyclopedia of Law, Corpus Juris and the later work on Cancellation and Recession, by Dr. Black. These works lay down principles such as where a perfectly valid contract is entered into and partially performed and then some law is passed or some official or arm of the government comes along and stops the work, then that contract ceases.

For instance, I call your attention to a case tried in Pennsylvania many years ago that is good law now, called the case of Cunningham vs. Fourth Baptist Church, 159 Pa. 620, and reported in the 28th Atl. Reporter at page 490, wherein a contractor agreed in writing to erect a church building, and during the progress of the building, the official inspectors, who represent the law and are an arm of the government, just as the Council of Defense was during the progress of this recent great war, stepped in and compelled certain material alterations. At the time of settlement the church refused to pay the difference or extra charge, and the contractor sued and recovered and the question was appealed to the Supreme Court of the state and there affirmed. This case, I believe to be quite in point, because it was a change in the law not contemplated by the parties when they entered into the original contract and the court simply implies this condition in it, that the extra work should be paid for, and that labor is worthy of its hire. This case has been followed and adopted in the recent edition of Corpus Juris. For, although the contract was lawful when made, if by a change of the law it becomes unlawful to fulfill, it is necessarily at an end, and cannot be enforced, and I cite you to the 9th volume of Corpus Juris, page 702.

Along this same line of thought is the case of Cordes vs. Miller, tried up in Michigan and reported in the 39th Mich. 581, and also in the 33rd American Reports at page 430, where a tenant entered into a contract of lease whereby he agreed to rebuild in case of fire. The building was frame and during the lease the city council passed a fire limit or building restriction ordinance whereby all buildings in a certain district were to be built of brick or stone. The building did burn and the court held the tenant released from the agreement to rebuild because the law by ordinance had changed the conditions and that it would be impossible to comply with it, and any arrangements they made or might make were outside the lease or contract, and the old lease ceased to exist.

In an Indiana case reported in the 66th Northeastern Rep. at page 1010, entitled Krause vs. School Board, a novel question somewhat in point arose, wherein the plaintiff Krause, as contractor, agreed by writing to erect an annex to a school building. At the time of the completion of all, except a small amount of finishing, the original building and annex burned and the school board sued the contractor for the amount they paid him for the annex, and the lower court sustained its view, but on appeal the Supreme Court reversed the trial court and held that there was an implied agreement in the contract, though not expressed, that the original building would remain so that the annex could be built and finished to it, and that full performance be made possible, and, further, that when the owners demanded of the contractor that he complete the building, such demand constituted a waiver of the contractor's failure to seasonably perform the contract. But keep in mind, gentlemen, the implied provision that the court injected into that express written contract, which rule may be applied to many of your cases.

Effect of Civil War on Contracts.—Now, during the Civil War, there was some litigation over the effect of war upon contracts, but I have failed to find much between parties not alien enemies, still the courts then laid down some general principles which are easily applicable to the pre-war contracts of the hour. For instance, one of the first questions that confronts you is the contract simply suspended during the war or by reason of some embargo caused by the war or military arm. This question seems to be finally answered by the Supreme Court of the United States in a series of cases involving insurance policies on the lives of certain individuals in Mississippi with New York companies when it was illegal to transact business with the enemy and thereby their policies lapsed and the insured died. These cases were tried under the case entitled New York Life Insurance Co. vs. Stratham, reported in the 93rd U. S. Rep., page 24, also in the 23rd L. Ed. 789. There Mr. Justice Bradley writes the opinion with but one dissent, saying these contracts have ceased, are ended and not merely suspended, and further says, "The truth is, that the doctrine of the revival of contracts suspended during the war is one based on considerations of equity and justice, and cannot be invoked to revive a contract which it would be unjust or inequitable to revive." And, further, that such failure being caused by a public war, without the fault of the assured, they are entitled ex equo et bono to recover the equitable value of the policies with interest from the close of the war and invokes the old law maxim in his opinion "that no man should be made rich by making another poor."

This case was followed by the West Virginia Supreme Court in the case of Abell vs. Pen. Mut. Life, reported in the 18th West Virginia Reports, page 400, where the court said: "The doctrine of revival of contracts, suspended by the war, after the cessation of hostilities, is based upon considerations of equity and justice, and cannot be invoked to revive a contract which would be unjust or inequitable to revive, as when time is the essence of the contract, or where parties cannot be placed upon an equal footing."

Now I think no lawyer will disagree with me upon the somewhat academic proposition that the law will excuse the parties from performing an impossibility and will be excused from performance by reason of vis major, a legal term meaning some irresistible, natural cause, which cannot be guarded against by the ordinary exertions of human skill and prudence, unless specifically mentioned in the contract. And otherwise, at least in most instances, the courts will come in and imply the condition precedent. In other words, it is presumed and implied that the parties would have guarded against this condition if they had known its existence at the time of contracting. And the courts agree that when the military arm of the government stays the work of a contract which was entered into prior to the war, and at a time when war and its results and effects could not be foreseen and contemplated, that such condition will be an excuse for non-performance such as will be a legal excuse for non-performance.

Now, another element enters into the discussion before we proceed farther with that, and that is the question of quasi contracts, which are really not contracts, but a mere fiction of the law to operate only when there is no contract. In other words, it is a contract by implication of the law. These are divided into two classes, those implied by law and those by fact and circumstances. I find in the 2nd volume of Elliott on Contracts, Sec. 596, this proposition laid down, that in the cases of quasi contract or contract implied by law, the liability arises from the facts and circumstances independent of the agreement or presumed intention. The intention of the parties in such cases is to be entirely disregarded, while in cases of express or implied contracts in fact, the intention is the essence of the transaction. The obligation arises not from consent, but from the law or natural equity.

And, further on, the author says in part, "and where the express contract is rescinded, or where both parties have departed therefrom, resort may be had in a proper case to an implied promise," and again, "the law will imply a contract when the parties attempt to contract, but their minds fail to meet on an essential element thereof, and no intention touching the question appears, and one party has executed his undertaking, and the other has accepted the benefits therefrom." This theory of law is adopted for the purpose of accomplishing justice and for the sake of the remedy to enforce the legal obligation created by law by action in form ex contractu.

English Decision on Pre-War Contract.—From the time of the decision of the Civil War cases there were scarcely any more decisions in the American courts that would be actually pertaining to the war as having a bearing on contracts. America has enjoyed the blessing of peace and the occasion did not arise to bring these questions before the court. It is queer that even the countries more belligerent than our own did not have many important decisions on these pre-war contract questions until the late war. We naturally look to England for our basic principles of common law. But even over in England the law was not satisfactorily settled and was more or less in a chaotic condition until the case of which you are now all more or less familiar, and of which every lawyer now knows, and that is the case of the Metropolitan Waterworks Board vs. Dick, etc., now reported in the American edition of the British Ruling Cases, Volume 8, at page 483, was tried in the House of Lords in 1918, and was one growing out of the late World War. And this decision reversed the finding of the lower court, where it was held the contract was only suspended. The contract provided the reservoir commenced under written contract in 1914, before the war, should be completed in six years. The war broke out. In 1916 the Secretary of the Ministry of Munitions served notice, with powers quite similar to our Council of National Defense, on the contractor to cease work on the contract for the general reason that the government needed the labor, fuel and machinery used by the contractor for munition work or other war work. The contractor complied. The Metropolitan Waterworks Board sued. The opinion written by the Lords was to the effect the contract was not suspended, but ended. That the suspension order was indefinite as to time, no one knowing when the war would be over or the extent the country would need the property and labor of the contractor. That after the suspension, conditions would be materially different, labor more scarce, fuel higher and more scarce, repairs harder to get, and more expensive, transportation slower and more inefficient, and in fact everything that the contractor must take into consideration in making up his bid has changed, become higher in price and more difficult to secure. If the work is resumed it is not the same contract at all.

I want to read you a few excerpts from the opinion in this case because I suppose, without doubt, this is the leading case now upon the subject. "The effect of the prohibition may be that the works cannot be resumed until, at all events, the greater part of the six years has expired, and by that time all conditions as regards labor and material may be absolutely different. This in the words of Rowkatt, J., would be 'not to maintain the original contract, but to substitute a different contract for it. * * * On the whole matter, I think that the action of the government is forced on the contractor as a vis major, has, in its consequences, made the contract, if resumed, a work under different conditions from those of the work when interrupted. I have already pointed out the effect as to the plant; and, the contract being a measure and value contract, the whole range of prices might be different. It would, in my judgment, amount, if resumed, to a new contract; and as respondents are only required to carry out the old contract, and cannot do so owing to supervenient legislation, they are entitled to succeed in their defense in this action. * * * Can it be said that a risk of this kind was in the contemplation of either party at the date of the contract? The necessary implication appears to me to be that it is a risk which no contractor would contemplate to be a risk under this contract, and which no public body controlling public funds would have regarded as a possibility effecting their liability in the absence of express provision. * * * I agree that the probability of hardship on one side or the other is not a matter of material consideration, but it is quite a different matter when there is an indefinite and indeterminate liability which might impose on either party an unforeseen burden totally foreign to the ordinary incidents in a contract of this character, or which might not improbably eventuate in a loss to both parties without compensating advantages. In my opinion, the original contracts have ceased to be operative. It may be well that at some future period the various works will be executed, but it will be under a different contract based on changed considerations. All of the prices will have to be fixed in reference to different conditions, and the time over which the work will be carried on will be wholly different. It is no answer that the engineer has certain powers over prices and time. These powers were incident to the original contracts, and were never intended to give the engineer a power to make new contracts binding either on respondents or appellants."

This case follows the English cases commonly called the Tamplin case, decided in 1916, and the Heilgers & Co. case, decided in 1917, by the House of Lords, thus fixing with certainty the binding precedents in Great Britain. There was one important point made, however, in the last named case, and that is the time to ascertain whether the adventure has been frustrated by the requisitioning of the chartered ship is when the requisition is made.

Decisions of the U. S. Supreme Court.—Now I am pleased to announce that this Dick case has been followed by the United States Supreme Court and in parts adopted. And, in one instance, in the case of North German Lloyd vs. Guaranty Trust Co., reported in the 244 U. S. at page 12, and also in the 37th Sup. Ct. Rep., 490, on May 7, 1917. This case is sometimes called the Kronprinzessin Cecilie case, which was the name of the boat that started from New York to Plymouth and Cherburg with certain kegs of gold on the eve of the outbreak of the war. At midsea the master received a radio announcing the possibility of war between Great Britain and Germany and the boat being a German one, the captain, on his own initiative, turned and returned to New York with the valuable cargo for fear of seizure in case of the outbreak before he could deliver the same. Now here was a case where war had not yet been declared, but the captain simply refused to risk the dangers. His judgment seemed to be good, for war was declared before he got back to America. The ship company breached its contract and the damages were probably quite great and were sued for such and the lower court sustained the claim, but on appeal Mr. Justice Holmes reversed the decision, and said in part, "We are wholly unable to accept the argument that although a ship owner may give up his voyage to avoid capture after war is declared, he never is at liberty to anticipate war. In this case the anticipation was correct, and the master is not to be put into the wrong by nice calculations that if all went well he might have delivered the gold and escaped capture by the margin of a few hours. In our opinion the event shows that he acted as a prudent man. * * * It was made in the usual form, and, as we gather, charged no unusual or additional sum because of an apprehension of war. * * * It is subject to the implied exceptions, which it would be extravagant to say were excluded because they were not written in. Business contracts must be construed with business sense, as they naturally would be understood by intelligent men of affairs."

Now, other American courts have held the contracts to be ended by reason of conditions making performance impossible by reason of this late war, and I simply refer to them because they are late. Such as In Re Boston Opera Co., 249 Fed. 269, and In Re Ferrari-Fontana, 249 Fed. 271; Thaddeaus vs. Hoffman, 160 N. Y. Supp. 973; Kneeland-Bigelow vs. Michigan Central R. R. Co. (Mich.), 174 N. W. Rep. 605; Moore & Tierney vs. Roxford Knitting Co., 250 Fed. 278, and, of course, there are others that do not come to my mind at present. This last case will probably be of great importance to you when it is decided by the Circuit Court of Appeals in the second circuit where it now is pending opinion, it having already been fully argued and decision due. It grew out of a sale of knit goods, a part of which was performed and delivered, when a member of the committee of the Advisory Board of National Defense wrote the manufacturer that the government was in need of and desirous of obtaining knit undershirts and drawers, and further saying: "I request you not to write me that you are sold up and cannot furnish any of these goods. I am aware this condition prevails with everyone. * * * "

The manufacturer complied with the request of the government and turned its further capacity over to the navy. The contractors sued for the damages caused by the breach. I deem the opinion handed down by the trial court as an able and righteous one. That this "request" was in fact an emphatic and peremptory order. The plaintiff had the right to rely on all he said and did. The right to believe and asssume that Cromwell and Fry (Defense Council) were representing the Secretary of War and Secretary of the Navy. Measures were taken to create, arm and equip, and clothe an immense army and navy, and the United States through its representatives were making known the emergency demands. I do not doubt that Congress had power to place these burdens on the manufacturer, and on those with whom they had contracted or with whom they should contract. The war power is paramount, arises from necessity, and no government can endure without its exercise on occasion.

Now there is just one more case I want to cite. It is an English case, entitled Bieber vs. Rio Tinto Co., growing out of the world war, where the court held that a provision in a contract for the sale of goods, the deliveries to cover a period of years, providing that in the event of war between the nations of the respective parties delivery under the contract shall be suspended and resumed at the end of the war is void as against public policy and on the outbreak of the war is nullified.

Contracts Cancelled by Implication.—I realize that you all have suffered by the war's effects on your contracts. It is seldom that two cases are alike. Probably some of my remarks are helpful to you and apply to your trouble and some it will not. But there is no doubt that an embargo placed upon your work through the arm of the government by reason of the war, stopping your work for an indefinite time that is, an uncertain length of time, would cancel the contract by implication. Then the important question arises, if you resumed your work when the restraint was lifted, are you working under the original contract or a new one? Circumstances may have happened to change the effect. Courts may differ on this question, of course. But, my belief is that you are, under most conditions, working under a quasi contract, which would entitle you to a reasonable compensation for what you have done since the old contract ceased to exist, unless you voluntarily, on your own initiative, and without coercion, threat or demand from the contractee, resumed the work after the delay caused by the governmental power.

Now, remember, you only have my opinion based, in a large part, upon the cases and text book authority I have cited you, yet there are many other recent English and some American cases quite in point that tend to strengthen this belief. However, there may be many lawyers who will disagree with me, as you know, law is not an exact science as civil engineering is. Great courts differ and great lawyers differ. In fact, the last United States Supreme case I cited you was decided by a divided court.

Controlling Tie Renewals

In Bulletin No. 223 of the American Railway Engineering Association, the Committee on Ties gives the result of a questionnaire sent out to all the principal railroads asking for information concerning methods in use for controlling and keeping records of tie renewals.

Replies were received from 58 roads, representing a mileage of 156,510. These replies were tabulated and a summary indicates:

Two Section Bulletin Board.

39 roads with a mileage of	87,460	keep no detailed data on life of ties.
5 roads with a mileage of	12,878	keep data on life of all ties in track.
21 roads with a mileage of	88,861	keep tie data by use of test sections.
24 roads with a mileage of	92,292	prefer method of test sections.
5 roads with a mileage of	12,526	prefer method of keeping data on life of all ties.
9 roads with a mileage of	27,556	consider information called for on forms 301, 302, 303 and 304 sufficiently valuable to justify its collection.
32 roads with a mileage of	108,080	do not consider this information sufficiently valuable or reliable to justify use of the forms.
20 roads with a mileage of	84,352	test section has superseded use of dating nail.
5 roads with a mileage of	8,388	test section has not superseded use of dating nail.
18 roads with a mileage of	80,858	use dating nail on test sections.
13 roads with a mileage of	24,569	do not use dating nail on test sections.
12 roads with a mileage of	26,352	recommend discontinuance of use of dating nail.
12 roads with a mileage of	54,101	recommend discontinuance of use of dating nail except on test sections.
14 roads with a mileage of	42,833	do not recommend discontinuance of use of dating nail.

Reclamation of Old Railway Material

The Committee on Conservation of Natural Resources of the American Railway Engineering Association has presented in Bulletin 221, recently issued, a resume of the various means taken by the railroads to conserve and reclaim what was formerly considered as scrap or waste material. The following is taken from an appendix to the report.

Many roads have taken up the subject of reclamation of material to such an extent as to erect shops equipped with special appliances for working over at small cost much of the worn and damaged material that formerly went into the scrap pile. They have found that rails with split and battered ends can be sawed into shorter lengths and used again on the main line; that worn and broken frogs and crossings, switch points and rail ends can be built up and welded, many of them in place, by means of the oxy-acetylene welding torch; that worn and bent anglebars, heated in an oil furnace, and placed in a die, can be swedged into their original sections by means of a drop-hammer. Some roads have found that oiling track bolts at regular intervals is an effective means for the conservation of labor and material. By proper oiling the bolts can be kept tight, with the result that there is a saving in labor and in wear on angle-bars and rail ends. This practice allows a great many bolts to be reclaimed during rail renewal that would otherwise find their way to the scrap pile.

All scrap around the stations and yards should be picked up and piled where it can be collected regularly. All train equipment such as marker lamps, air hose, brake shoes, and car doors found along the track should be shipped to the motive power department, where it can be used again.

Steel bridges that have become too light for main line traffic may in many cases be sufficiently strong to carry branch line traffic for several years, while those replaced on the branch lines may be used for interurban or highway service.

Many roads are finding the sawmill a useful agency in the conservation of timber. Old stringers that formerly were used for platforms, runways, sidewalks, culverts, foundations, retaining walls and back walls in pile and frame trestle bridges can be sawed so as to recover a great deal of valuable lumber.

Much of the lumber that is being used for signs and crossings might be conserved by substituting other materials more permanent and in many cases no more expensive than wood. For example, an old boiler flue encased in concrete at one end and flattened at the other end to receive a 1/16-in. steel plate for the lettering or notation makes a very attractive sign where properly painted and requires very little expense to maintain. Public crossings could be made very satisfactorily out of reinforced concrete slabs or out of crushed stone or other ballast materials held in position by a bituminous binder.

Old buildings along the line that cannot serve any useful purpose in their present location or elsewhere should be torn down and all of the material reclaimed and used where they can be made to serve some useful purpose.

In many cases the old ties removed from the track can be utilized. Some of them can be used for cribbing, some can be cut for fuel, and some from the main track can be used over again in yard tracks and sidings. Those intended for fuel can be disposed of to company employes or to farmers adjoining the right-of-way, or they can be used for engine fuel at division points, at water-stations, or at other places along the line. None, however, should be burned if they can possibly be used for any purpose.

Pile-heads that in many cases were thrown away can now be made to serve a useful purpose. The elm and maple pile-heads can be sawed and turned into jack and cant-hook handles; oak pile-heads can be sawed into center and ballast stakes; while cedar pile-heads can be sawed into shingles.

There are always more or less odd-size timbers left over after the construction of buildings. Instead of such lumber allowed to accumulate in the material yard from time to time it should be re-sawed to such suitable dimensions as will allow it to be used at once.

On account of decay, or for other reasons, it frequently becomes necessary to renew certain timbers in wooden structures, even though only a very small portion of the member removed fails. If these are properly sawed they can be used again for smaller pieces in the same structure, or if this is not feasible they can be sent to the sawmill to be worked into usable sizes for other purposes.

An instance of reclaiming timber is given as that of a large ore dock at Marquette, Mich., containing 4,200,000 ft. B.M. A portable sawmill was installed and as fast as the old lumber was taken from the ore dock, it was sawn into shorter lengths and smaller sizes suitable for a greater variety of uses. The total amount sawed was 1,030,000 ft. B.M., costing $5.69 per M ft.

On one large railway system the material is divided and sorted into three classes, viz.: Scrap for sale, material fit for further use, and material to be repaired for further use. One factor in reclaiming material is that of safety, as every item reclaimed is put in a perfect condition for all practical purposes.

Below is a list of a few of the things that are being done by the reclamation plants on this railway:

1. Bolts and nut locks reclaimed during one month to the amount of $599, at a total cost of $89; thereby effecting a saving of $510.
2. During one month 27,065 lb. of nuts of various sizes were reclaimed by sorting carefully and re-tapping; net saving, $722.31.
3. Reclaimed 190 car roofs at $4.94 each, as against $35 new; saving, $5,711.40.
4. Reclaimed 1,743 lb. of lag screws by rattling until bright as new, at a saving of $133.72.

They are doing such work as welding cast-iron spokes on driving wheels; building up worn spots on firebox castings with acetylene welding; mating and pairing flange worn steel-tired wheels before turning, thereby saving a great deal of labor; reclaiming salt deposits from refrigerator cars for use in thawing switches during the winter and for use in fire barrels; pressing oil from waste (one barrel of waste netting about 20 gal. of oil), and burning the waste and reclaiming about 50 lbs. of babbitt (this reclaimed babbitt is as good as new); reclaim barbed wire for use in building rip-rap.

General Reading for Technical Students.—It is possible for an engineering student who has determination and will to use some leisure time in this way, to plan and carry out a useful course of reading in the English classics, and by careful observation of the style of what he reads, and with some practice in writing, to form an easy and effective style. There is no need of his taking a correspondence course. Let him start with George Herbert Palmer's "Self-Cultivation in English" (Houghton Mifflin Company) and a good book on English composition like Lamont's "English Composition" (Scribners); then go to the classics themselves, say in such series as the World's Classics (Oxford University Press), Everyman's Library (Dutton), or the Riverside Literature Series (Houghton Mifflin Company), and read in such directions as his inclination leads him—history, general science, biography, poetry, drama, fiction. He will soon discover what he likes best and may follow up that line with infinite profit and delight. All he has to do is to read thoughtfully and with a mind ready for comparisons, just as he would read an engineering treatise, and to keep at it systematically and resolutely.—Clark S. Northup in Cornell Civil Engineer.

Cost of Reconstructing Street Railway Track.—The average labor costs for 1919 for track reconstruction on the Eastern Massachusetts Street Ry. was 91 ct. per foot, according to a statement of the chief engineer in the February AERA. This figure is for replacing 60-lb. T-rail with 80-lb. rail and new ties, the track being located in center of gravel road and under 8-minute service. Old gravel was hauled away by work train and replaced with new to top of rail. The cost includes platform expense only on work train. The unit costs of the work are given as follows:

	Per Ft.
Grading to bottom of tie	$0.54
Track laying	.195
Material haul	.068
Bonding	.040
Watchman and lamps	.040
Foreman and timekeeper	.027
Labor at 55 ct. per hour	.....
Total	$0.910

A Comparison of Steam and Electric Motive Power

Mr. A. H. Armstrong, of the General Electric Co., recently delivered an address with the above title before the Schenectady section of the American Institute of Electrical Engineers. We quote below some figures from his address:

During the winter of 1917-18 our railways fell down badly when the need was the greatest in their history. It is true that the cold weather conditions were unprecedented and the volume of traffic abnormal, but the weaknesses of steam engine haulage were disclosed in a most startling and disastrous manner. Delayed passenger trains in cold weather can be endured by the traveling public in suffering silence or voluble expression, according to temperament, but blocking our tracks with frozen engines and trains, serious reduction of tonnage in cold weather and the prohibitive delay in transportation of freight in times of great stress is quite another thing and plainly indicates the inability of the steam engine to meet overloads and adverse climatic conditions.

In marked contrast to the adjoining steam engine divisions, the 440 miles of electrified section of the Chicago, Milwaukee & St. Paul R. R. continued to do business as usual all through that trying winter of 1917-18. The electric locomotives brought both freight and passenger trains over the electrified tracks on schedule time or better; in fact, it was quite customary to make up on the 440-mile electric run fully two hours of the time lost by passenger trains on adjoining steam engine divisions. While the results obtained upon the Chicago, Milwaukee & St. Paul R. R. were perhaps more spectacular due to the greater mileage electrifically equipped, other electrified roads contributed similarly attractive records. The reliability and permanency of the comparison between steam and electric locomotive haulage is sufficiently guaranteed therefore by the results of several years' operation, to justify drawing certain conclusions regarding the merits of the two types of motive power.

The tonnage passing over the tracks of our railways may be subdivided in a most interesting manner as shown below:

TOTAL TON-MILE MOVEMENT ALL RAILWAYS IN UNITED STATES, YEAR 1918.

	Per cent.	Ton miles.
1. Miscellaneous freight cars and contents	42.3	515,000,000,000
2. Revenue coal cars and contents	16.23	197,000,000,000
3. Locomotive revenue driver weight only	10.90	132,300,000,000
4. Passenger cars, all classes	16.13	196,000,000,000
Total revenue, freight and passenger	85.56	1,040,300,000,000
5. Railway coal	5.00	60,600,000,000
6. Tenders, all classes	6.50	78,800,000,000
7. Locomotive, railway coal	.39	4 700,000,000
8. Locomotive, non-driving weight	2.55	31,000,000,000
Total non-revenue	14.44	175,100,000,000
Grand total, all classes	100.00	1,215,400,000,000

The first four items, representing 85.56 per cent of the total ton mile made during the year 1918 may be regarded as fundamentally common to both steam and electric operation. The last four items, however, are seriously affected by introducing the electric locomotive to the extent of completely eliminating items 6 and 7, reducing item 5 by possibly 80 per cent and item 8 by one-half. Of the total of 14.64 per cent affected, therefore, it may be assumed for purposes of comparison that approximately 12 per cent of 146,000,000,000 ton miles at present hauled by steam engines over our roads will be totally eliminated with electric locomotive haulage. This ton mileage eliminated is equal to over 20 per cent of items 1 and 2 representing the revenue producing freight traffic on our railways. In other words, if all our railways were completely electrified they could carry one-fifth more revenue producing freight tonnage with no change in present operating expenses or track congestion.

Even with coal as a source of power, it may not be fully appreciated just how enormous is the saving made by burning fuel in large modern power stations under the most efficient conditions possible, instead of under the boilers of 36,000 engines, which by necessity must be designed and operated for service rather than for fuel economy. During the year 1918 the fuel used by railways is reported as follows:

Total coal production—all grades	678,211,000 tons
Used by steam railways	163,000,000 tons
Percentage of total	24 per cent
Total oil marketed, U. S.	355,927,000 bbl
Used by steam railways	45,700,000 bbl.
Percentage of total	5.8 per cent

Coal equivalent of oil at 3½ bbl..........	13,000.000 tons
Total equivalent railway coal..............	176,000,000 tons

A quarter of all the coal mined in the United States is consumed on our railways and the following analysis will point out some features of this extreme wastefulness which are inseparable from steam engine operation.

During the year 1910, exhaustive tests were made upon the Rocky Mountain division of the C., M. & St. P. to determine the relation existing between horse power hours work done in moving trains and coal and water consumed on the steam engines in service. The following summary gives the result of these tests:

COAL AND WATER USED.

	Water per hp.	Water per lb. coal.	Coal per hp. hr.
Three Forks-Piedmont	39.6	5.08	7.75
Piedmont-Donald	35.4	4.70	7.54
Deer Lodge-Butte	39.7	4.85	8.31
Butte-Donald	40.4	4.86	8.74
Harlowton-Jenny	38.0	4.09	8.90
Jenny-Summit	44.2	4.65	9.48
Three Forks-Piedmont	41.4	6.51	6.37
Piedmont-Donald	40.2	5.63	5.78
Average of 8 tests................	39.86	5.04	7.86

The above records were obtained during the portion of the runs that the engines were doing useful work in overcoming train and grade resistance, that is, all stand-by losses were excluded. The through run, however, included such losses in the following magnitude.

Adding standby losses to the average of 7.86 lb. per horsepower obtained in the preceding eight tests, the total actual coal consumed under the engine boiler in 24 hours divided by the actual work performed by the engine was found to be 10.18 lb. per horsepower at the driver rims.

STANDBY LOSSES.

	Coal per hour.
Fire banked in roundhouse...........................	150 lb.
Cleaning fires for starting..........................	800 lb.
Coasting down grade..................................	950 lb.
Standing on passing track............................	500 lb.

As the result of this particular series of tests it was determined that standby losses raised the coal consumed while doing useful work by 30 per cent. It should be appreciated in this connection, moreover, that this value was obtained on through runs with no yard switching service or adverse climatic conditions. It may be concluded therefore that under all conditions of service fully one-third the coal burned on our steam engines today is absolutely wasted in standby losses of the general nature indicated above.

Supplementing these tests, a 30-day record was kept of all coal used on the entire Rocky Mountain division and the total engine, tender and train movement reduced to horsepower hours, resulting in a value of 10.53 lb. coal consumed per horsepower at the driver rims. Both the above values were based upon constants of 6 lb. per ton train resistance at all speeds and 0.7 lb. per ton per degree of curvature as determined in part by dynamometer car tests and representative of general railway operation. Reducing the average coal values of test runs and 30-day record per horsepower hour to electrical constants we arrive at the following results:

COAL EQUIVALENT PER KW. HR.—STEAM OPERATION.

Coal per hp. hr. at driver rims..............................	10.27 lb.
Coal per kw. hr. at driver rims..............................	13.75 lb.
Coal per kw. hr. at power supply on basis 55% efficiency..	7.56 lb.

It is this last figure of 7.56 lb. of coal burned on steam engines to get the equivalent tonnage movement of 1 kw. hr. delivered from an electric power station that is of special interest to this discussion. Comparing coal and electrical records on the Butte, Anaconda & Pacific R. R. before and after electrification results in arriving at a value of 7.17 lb. of coal previously burued on the steam engines to equal the same service now performed by one kilowatt hour input at the substations, a figure comparing favorably with 7.56 lb. above arrived at by an entirely different method.

Making due allowance for the fact that Roundup coal is somewhat low in heat units, it is nevertheless within the limits of reasonable accuracy to assume that steam engines operating over all our railways are consuming coal at a rate closely approximating 12.75 lb. of coal per kilowatt hour of useful work done, as measured at the driver rims or 7 lb. per kilowatt hour as measured at a power station and including for convenience of comparison the transmission and conversion losses inherent to electrical operation.

An electric kilowatt can be produced for so much less coal expendiutre than 7 lb. that we are now in position finally to forecast the approximate extent of the coal economy that would result from electrification.

RELATION BETWEEN KW. HR. AND TON MILES—C., M. & ST. P.—AVERY-HARLOWTON—YEAR 1918.

	Passenger.	Freight.
Average weight locomotive.......	300 tons	284 tons
Locomotive miles 1918............	651,000	1,431.500
Locomotive ton miles.............	195,000,000	407,000.000
Trailing ton miles...............	434,406,000	2,903,099,000
Total ton miles..................	629.406.000	3,310.049,000
Kilowatt hours...................	24.890,000	105,287,000
Watt hours per ton mile..........	39.6	31.9
Ratio locomotive to total........	31%	12.3%
Watt hours per ton mile combined movement..............	33.2	
Ratio locomotive to total combined movement	15.25%	

The actual equivalent coal consumed on our steam railways for the year 1918 is given as 176,000,000 tons, closely approximating the figure of 170,000,000 tons estimated above from the operating results obtained on the C., M. & St. P. electrified zone. These several values check so closely as to justify the completion of the fuel analysis of the railways, shown below:

COAL SAVING BY ELECTRIFICATION.

Total ton miles steam..................	1,215,400,000,000
Reduction by electrification...........	146,000,000.000
Total ton miles electric...............	1,069,400,000,000
Kw. hrs. electric at 40 watts..........	42,776,000,000
Coal on basis 2½ lb. per kw. hour.....	53,500,000 tons
Equivalent railway coal 1918...........	176,000,000 tons
Saving by electrification..............	122,500,000 tons

The startling conclusion arrived at is that approximately 122,500,000 tons of coal or more than two-thirds the coal now burned on our 63,000 steam engines would have been saved during the year 1918, had the railways of the United States been completely electrified along lines fully tried out and proved successful today. This vast amount of coal is 50 per cent greater than the pre-war exports of England, and twice the total amount consumed in France for all its railways and industries. Moreover, the estimate is probably too conservative, as no allowance has been made for the extensive utilization of water power which can be developed to produce power more cheaply than by coal in many favored localities.

On the C., M. & St. P. R. R., 42 locomotives have replaced 112 steam engines and are hauling a greater tonnage with reserve capacity for still more. One this and other roads, it has set a new standard for reliability and low cost of operation. In fact, although no official figures have yet been published, it is an open secret that the reduction in previous steam operating expenses on the C., M. & St. P. R. R. are sufficient to show an attractive return upon the $12,500,000 expended for the 440 miles of electrification, without deducting the value of the 112 steam engines released for service elsewhere.

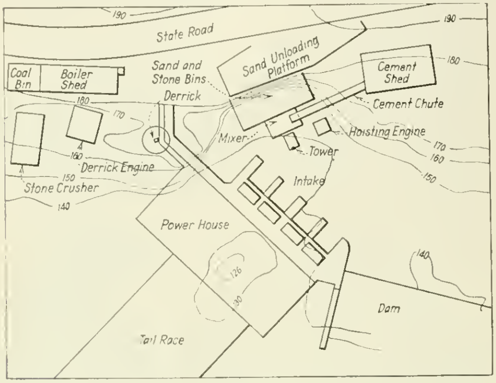
Tractor Replaces Teams in Loading Maney Scraper

A tractor is being employed by the Hornaday Construction Co. of Memphis, Tenn., in loading Maney scrapers on a grading job, requiring the moving of reasonably hard street earth. The tractor takes the place of a 4-up team. By this method of loading the scrapers are filled to full capacity of 1 cu. yd.

Lamson Tractor Loading Maney Scraper.

Construction Plant Lay Out Eliminates Man Handling of Material

An excellent example of the utilization of a side hill for a construction plant installation is afforded by the operations at Dashville Falls in the Wallkill River near Rifton, N. Y., where a small dam and power house are being built by the J. G. White Engineering Corporation.



Construction Plant Layout for Dam and Power House Development at Dashville Falls, N. Y.

The plant covers the entire job at the first set-up. A derrick with 80-ft. boom is placed so as to reach over the entire powerhouse area and part of the tail race. It is being used in handling rock excavation of the wheel pits and power house foundations, also the tail race. After the excavation is completed it will be used in erecting steel work for the power house and installing machinery.

The stone crusher on the side hill is so placed that it is fed by the derrick with rock from the power house and tail race excavation. Below the crusher is approximately 400 yd. storage space on the side hill for crushed rock. The concrete mixing plant is so placed that the entire power house area and main section of the dam between the falls and the power house can be reached by the tower and chute. The remaining section of the dam requiring approximately only 250 yd., which extends for 200 ft. above the falls, is out of reach of the chutes and will be easily poured by the use of concrete buggies.

The storage bins for sand and rock have been so placed in a recess in the rock that the entire elevation from the road level to the bottom of the fall can be utilized. These bins provide storage space for 125 yd. of sand and 250 yd. of rock. The sand is delivered over the concrete state road from a pit 2 miles distance and is loaded into the bin by dropping the tail gate of the truck. The crushed rock is loaded into the bin by means of the derrick with a re-handling bucket from the crushed rock pile below the crusher.

The boiler shed and coal bin are so located that coal can be unloaded from a truck by gravity from the state road. The cement shed is so located that cement also delivered by truck can be unloaded by dropping its tail gate. The only handling necessary is in placing the cement in the shed. The cement chute from the shed to the mixing platform is housed in so that concreting can be carried on in any kind of weather.

Tree Planting to Serve as Railway Snow Fences

Tree planting by railways is not a new thing. Some years ago when the scarcity of timber began to be felt a number of railways began in a small way the reforestry of cut-over lands with a view chiefly to the growing of ties. The success of these experiments has not been very gratifying on the whole, due to a variety of causes. One experiment which did not turn out as expected was nevertheless quite succesful is described in a recent bulletin of the American Railway Engineering Association as follows:

In 1907 the Santa Fe Ry. undertook to make experimental plantings of Eucalyptus for the purpose of replenishing the supply of timber for ties. Mr. Pinchot's statement at the time was that a continuation of the then rate of consumption of timber with the same yearly percentage of increase would exhaust the available supply of hardwoods in the United States in about 25 years, and of conifers in about 40 years.

In the following 7 years 2,250 acres were planted near Del Mar, San Diego County, California. The land was not considered suitable for other agricultural uses and was obtained at a moderate cost per acre. It developed that there was not sufficient rainfall to support a vigorous or even reasonably

General View of Construction Plant of J. G. White Engineering Corporation at Dashville Falls Job.

satisfactory growth of the trees, and in seeking a remedy for this condition an underground water supply of such extent was discovered on the property that the land was immediately put in the agricultural class, and it became uneconomical to use it for the growing of Eucalyptus commercially. Sufficient water (700 miner inches) was discovered to irrigate about 4,000 acres. For this reason it was decided to develop the property as irrigated agricultural land and considerable quantities of trees which had been planted were taken out in order that the land might be farmed.

About this time parties owning valuable water rights and a dam site in the vicinity asked to co-operate with the Santa Fe Ry., and a water company has been formed to serve such land as could be properly taken care of from these sources. In this way and by the extension of ditches where possible to adjoining land, about 20,000 acres will be put into the irrigated land class and so a more valuable conservation of natural resources accomplished than by the original scheme of planting Eucalyptus.

The planting of trees for wind breaks has long been practiced by private individuals, so it was quite natural that in northern latitudes where heavy snows were common, for the railways to consider tree planting as a substitute for the rather expensive snow fence. In the same bulletin noted above some experiences of the Canadian railways are given which seem to have been very satisfactory. The following is taken from the report of the Committee on Conservation of Natural Resources, contained in Bulletin No. 221:

The pioneer in railway tree planting in Canada is the Intercolonial, now a part of the Canadian National Railways System. The initiation of this work resulted from the very severe winter of 1887, when the snowfall in New Brunswick was very heavy, with almost continuous high winds, so that only with the greatest difficulty could the cuts be kept clear of drifting snow and train service be maintained.

The then roadmaster finally decided that the planting of spruces along the edges of the right-of-way, between Campbellton and Bathurst, N. B., would, after a few years, be much more effective than the board fences previously in general use. Through a period of years, beginning with the spring of 1888, the work of planting was accordingly continued.

Spruces from 18 in. to 3 ft. high were planted and after these reached a height of 9 to 10 ft., the tops were trimmed, as well as the longer side branches, to give a hedge effect. After the hedges had reached about 4 ft. in height, the wooden snow fences were removed, thus stimulating the growth of the trees. It was found by experiment that planting at about 75 ft. from the track gave the best results.

About 7 years after planting, the hedges gave much better protection from drifting snow than had the board fences, besides being a decided ornament, from a scenic viewpoint. Destruction of the plantations by fire is guarded against by burning off the dry grass in the early spring, under careful supervision.

In the west, the leader in railway tree planting has been the Canadian Pacific Ry. On its western lines, this company maintains a large nursery at Wolseley, Saskatchewan.

In addition to supplying large numbers of trees to prairie farmers for the planting of windbreaks, shelter-belts and woodlots, the company does a very considerable amount of planting each year on its right-of-way, with a view to the establishment of live snow fences. The fact that on the company's main line in the prairie provinces, the right-of-way is 200 ft. wide, makes it possible to carry on this work advantageously on its own property. Planting closer than 75 ft. from the track is not desirable.

Due to the light precipitation, much care has to be taken in preparing the soil for prairie planting, particularly in Southern Alberta. After plowing, sufficient time, six months to a year, must be allowed for the sod to decay, after which it is back-set, or plowed 2 or 3 in. deeper than the first plowing. The ground is then summer-fallowed for one year. Then, in the third year it is ready for planting.

The trees thus far planted for snow fences are for the most part of the hardwood or deciduous-leaved species, including carangana, willow and poplar. It is believed that underplanting with spruce will prove desirable, after the hardwoods have become well-established. Great care must be observed in details of selection of species, spacing of trees, width of belt, etc., in order to attain satisfactory results. Conservation of soil moistures must be aimed at in all phases of the operations. Under favorable conditions the plantation must be cultivated for at least three years, or until the crown cover has become sufficiently dense to reduce evaporation to a minimum.

Costs vary with local conditions, but the experience of the company indicates that over a period of years a snow fence of trees has decided advantage over the old-style board fence in respect of both efficiency and economy.

On the eastern lines of the Canadian Pacific Ry. tree planting is under way in selected localities with a view to the control of drifting sand, as well as for protection against snow drifting into cuts. Drifting sand, for example, has caused hot boxes, fences have been covered with sand, allowing cattle to stray on the track, and passengers have suffered from dust.

For the prevention of drifting sand, the species most used are Scotch pine and Carolina poplar. The former is making a growth of about 12 in. a year, and the latter about 3 ft. Experience shows, however, that the planting of conifers (pines, spruces, etc.) is to be preferred for this purpose. The results secured are satisfactory to the company and the work is being continued and extended at various points in Quebec, where drifting sand has caused trouble.

To prevent snow drifting in cuts, considerable tree planting has been done on Canadian Pacific eastern lines. The planting of conifers is greatly preferred, species native to the locality being used. Thus, along the north shore of Lake Superior, jack pine and spruce are utilized; in Quebec, spruce, balsam and cedar, and in Maine and New Brunswick, spruce and balsam. In addition, there has been some planting of white pine, red pine, cedar and hemlock, and in wet spots alder and willow. Trees planted are generally not over 30 in. in height.

Planting is generally 75 ft. from the track. With conifers two rows are planted; the rows are 3 ft. apart, and the trees 3 ft. apart in the rows, staggered. To secure equally good results with hardwoods, it is considered that the planting of eight rows would be necessary.

Soil preparation consists of plowing and harrowing, removing heavy sods, in the spring or autumn preceding planting. Cultivation is necessary for about three years.

The company considers that the cost of this method of securing protection from drifting snow is only one-third to one-half as much as with wooden snow fences, besides being more effective, after about seven years from the time of planting.

Resistance of Greenheart to Various Marine Borers.—The extent to which greenheart timber resists attack by various kinds of marine borers is being ascertained in a test conducted by the Forest Products Laboratory, Madison, Wis. Six years ago the laboratory placed specimens of this wood in the Gulf of Mexico. In waters infested with pholas, xylotrya, and limnoria. A recent examination of the timbers showed that, except for a very slight trace of limnoria on the sapwood of one specimen, they had been uninjured by either xylotrya or limnoria, although these borers are very active in this vicinity. All the timbers, however, were severely attacked by pholas. The surfaces of each specimen were covered with burrows from ¾ in. to 1½ in. deep. How far these burrows will extend with continued exposure remains to be seen, but it is not expected that they will extend much more than 2 in. Pholas have not been found to bore very deep in wood. It is evident, however, that greenheart piles for use in pholas-infested waters should be made large enough to allow for reduction in size by pholas attack.

Cost of Living in Great Britain.—The British (official) Labor Gazette, in a review of prices during the year 1919, states that the average increase in the retail prices of food on January 1, 1920, was 136 per cent, compared with July, 1914, while the general increase in the cost of living, including house rent, fuel, and light, was 125 per cent. These percentages are averages for the whole country. As showing the general upward tendency the following tables are given:

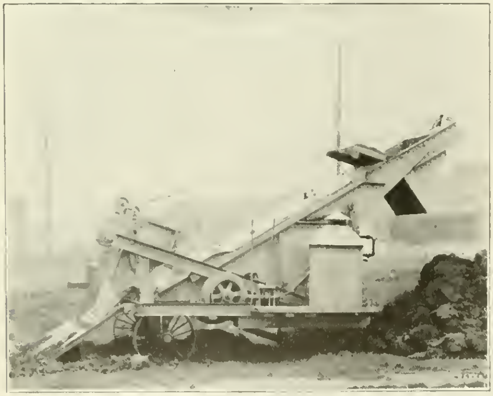
	Increase over July, 1914.	
	Food prices. Per cent.	General prices. Per cent.
Jan. 1, 1919	130	120
June 1, 1919	104	105
Jan. 1, 1920	136	125

Effect of Electric Operation on C. M. & St. P. Ry. on Track and Rails

The consensus of opinion of the roadmasters and superintendents on the electrified zone, according to the report of the Committee on Electricity of the American Railway Engineering Association, in Bulletin 221 of the association, is that there is no more slipping of the locomotive wheels on the rail and consequently no more damage to the top of the rail under electric operation than there is with steam locomotives. It has not been found that there is any greater tendency for the rails to creep on account of regenerative braking on descending grades than there was under the braking action of steam locomotives. No case has been found where electric locomotives moving at a high rate of speed have tended to displace the rail on the ties or the ties in the ballast. Roadmasters agree that the electric locomotive is easier on the track than steam locomotives because of the less rigid construction. It is stated that the flange wear on curves under electric operation is actually less than under steam operation, for the reason that the electric locomotives are less rigid in their wheel arrangement than the steam locomotive. On curves the outer rails are elevated for 30 miles per hour on mountain grades and for 45 miles per hour for valley territories. On the Rocky Mountain and Missoula Divisions the mountain grade superelevation is ½ of 1 in. to 1° of curvature with a maximum of 3 in. On other curves the superelevation is 1 in. per degree with a maximum of 3½ in.

New Excavating and Loading Machine

The T. L. Smith Co., Milwaukee, Wis., has recently brought out the new excavator and loader illustrated below. Only two men are necessary to the operation of this machine; one at the operating levers and one at the loading point. At a point anywhere within 50 to 200 ft. from the machine is stretched a chain, at right angles to the line of digging; upon this chain are two sheaves, hooked to the chain; either sheave may be unhooked and re-located in an instant. One heavy cable passes from the hoist drum on the machine, then to the digging skip, then through both sheaves, back to the retrieving hoist drum on the machine.



New Model K Excavator and Loader.

The operator at the machine manipulates but two levers and a foot brake. As he places power on the digging line, the other man manipulates the handles on the slip, so as to fill it with the material to be dug or removed. The slip has a capacity of 15 cu. ft. per trip. As soon as the slip is filled, the man releases the handles and allows the slip to ride to the excavator. As the slip strikes the apron at the machine it unlocks the catch of the pivot arm on the machine. The arm then carries the slip up over the machine and onto a slanting chute located on the front of the machine from where the material in the slip discharges into the waiting wagon, truck or railroad car. The slip is then quickly retrieved to the starting point and the operation repeated.

Personals

F. A. Torkelson has resigned as city engineer of Marquette, Mich.

William Hood has been appointed chief engineer of the Southern Pacific Ry.

T. J. Wyche has been appointed chief engineer of the Western Pacific R. R.

A. H. Porter has been appointed engineer of the Charleston-Carolina R. R.

F. B. Freeman has been appointed chief engineer of the Boston & Albany R. R.

P. D. Fitzpatrick has been appointed chief engineer of the Central Vermont Ry.

T. H. Gatlin has been appointed chief engineer of construction of the Southern Ry.

Capt. Charles C. Crotty has been appointed assistant port director of Houston, Tex.

Frank Merritt has been appointed chief engineer of the Gulf, Colorado & Santa Fe R. R.

Samuel T. Wagner has been appointed chief engineer of the Philadelphia & Reading Ry.

H. H. Temple has been appointed chief engineer of the Pittsburgh & West Virginia R. R.

A. W. Newton has been appointed chief engineer of the Chicago, Burlington & Quincy R. R.

Robert C. Falconer has been appointed assistant to the president and also chief engineer of the Erie R. R.

C. L. Barnaby has been appointed division engineer of the Fort Wayne Division of the Pennsylvania R. R.

R. B. Robinson has been appointed engineer maintenance of way of the Union Pacific R. R., with office at Omaha.

W. H. Kirkbride has been appointed engineer of maintenance of way and structures for the Southern Pacific R. R.

R. G. Kenly has been appointed assistant to the president of the Minneapolis & St. Louis R. R. and also chief engineer.

W. W. Morrison has been appointed chief engineer of the Pittsburgh & Shawmut R. R., with headquarters at Kittanning, Pa.

F. S. Schwinn has been appointed chief engineer of the International & Great Northern Ry., with headquarters at Palestine, Tex.

F. I. Cabell has been appointed chief engineer of the Chesapeake & Ohio Ry., and J. P. Nelson has been appointed valuation engineer.

Lieut.-Col. Earle B. Morden, formerly constructing engineer for the Great Northern Ry., has been appointed chief of the street cleaning bureau of Philadelphia, Pa.

William A. Heindle has resigned as general superintendent of the Wilmington & Philadelphia Traction Co. and will engage in an engineering and contracting business at Wilmington, Del.

R. C. Gowdy has been appointed chief engineer and W. H. Hess valuation engineer of the Colorado & Southern Ry., the Wichita Valley Ry., and the Fort Worth & Denver City Ry. M. A. Stainer has been appointed engineer maintenance of way of the two last named railroads.

Gabriel R. Solomon, recently colonel U. S. A., officer in charge of engineering branch Construction Division of the Army and formerly of Solomon-Norcross Co., Consulting Engineers, Atlanta, Ga., has resumed engineering practice as vice-president of the Fuller Industrial Engineering Corporation, 949 Broadway, New York City.

F. J. Stimson, superintendent of the Richmond division of the Pennsylvania R. R., has been promoted to be chief engineer of maintenance of way of the southwestern region of the system, with headquarters in St. Louis. A. C. Watson, former assistant division engineer of the Richmond division, was appointed to be superintendent of the Richmond division.

D. Q. McComb, until recently highway engineer, U. S. Bureau of Public Roads, resigned March 1 from the Federal service to accept appointment as division engineer, Tennessee Highway Department. A few months ago he was honorably discharged from the military service as major, Third Engineers, United States Army. Major McComb is an engineer of 12 years' practical experience in the Philippine government service, with the Pittsburgh Testing Laboratory, Birmingham, Ala., with the Corps of Engineers, United States Army, and with the Bureau of Public Roads.

A. C. Shand has been appointed chief engineer and E. B. Temple, Robert Trimble and J. F. Murray assistant chief engineers of the Pennsylvania R. R., with headquarters at Philadelphia, Pa. Other appointments include: H. R. Leonard, as engineer of bridges and buildings at Philadelphia; J. C. Bland, as engineer of bridges and buildings with offices at Pittsburgh; W. H. Cookman, as architect for the system with offices at Philadelphia; C. A. Preston, as valuation engineer with offices at Philadelphia; W. C. Cushing, who is now chief engineer of maintenance at Pittsburgh, to be engineer of standards and valuation at Philadelphia; A. H. Rudd, now signal engineer for the eastern lines, to be chief signal engineer for the system, with offices at Philadelphia.

Industrial Notes

The Advertising Engineers, specialists in technical advertising, have opened offices at 180 N. Market St., Chicago, and 50 Union Square, New York. Victor Hugo Halperin in charge of the western office and Curtis F. Columbia is in charge of the eastern.

Horace D. Kerr, formerly with the Atlas Portland Cement Co., as engineer in charge, western technical department and western service department, has resigned and joined the staff of The Nichols-Moore Co., General Advertising Agents, Cleveland.

The Garford Motor Truck Co., Lima, O., has established a transportation engineering department, the duties of which will be to gather authoritative information on the operation of motor trucks and to aid present owners to obtain the lowest cost per ton mile.

The Portland Cement Association announces the opening of a new association office in Portland, Ore., at 146 Fifth St., with Hans Mumm, Jr., as district engineer in charge. Since 1903 Mr. Mumm has been engaged in various engineering work in Washington, having been County Engineer of Snohomish County from 1912 to 1915, and the year following City Engineer of Everett, Wash. Mr. Mumm joined the staff of the Portland Cement Association in 1916, since which time he has been identified with association work in Washington.

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Roads and Streets—1st Wednesday
(a) Roads
(b) Streets
(c) Street Cleaning
(d) Municipal Miscellanies
(e) Management and Office System

Waterworks and Hydraulics—2nd Wednesday
(a) Waterworks
(b) Sewers and Sanitation
(c) Irrigation and Drainage
(d) Power and Pumping
(e) Management and Office System

Railways and Excavation—3rd Wednesday
(a) Excavation
(b) Management and Office System
(c) Quarries and Pits
(d) Steam Railways, Construction and Maintenance
(e) Electric Railway Construction and Maintenance

Buildings and Structures—4th Wednesday
(a) Buildings
(b) Bridges
(c) Harbor Structures
(d) Miscellaneous Structures
(e) Properties of Materials
(f) Management and Office System

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Can There Be a Non-Partisan President?

Can there be a non-partisan president of the United States? This is the question that Hoover has seriously raised for the first time in a century. Most of the "independent newspapers" have apparently answered the query in the affirmative. Not a few of the one-time "party organs" also show decided leanings toward assisting in bringing about the election of the man who has frankly declared himself to be non-partisan.

Let us try to answer the question by asking and answering a parallel question: Can there be a non-partisan mayor of a city? Several hundred American cities have in effect replied "Yes," for they have abandoned the old idea of voting for a "city commissioner" or for a "city manager" because he belongs to a political party. A "city manager" performs all the functions of a mayor, and many of the functions of a city council or board of aldermen. In cities that have adopted the commission manager form of government, party politics has either died or is on its death bed. Why, then, is it incongruous to speak of electing a non-partisan president when we already have many non-partisan city managers? A president differs from a mayor only in respect of the size of the political unit whose executive head he is.

In this connection it may be worth noting that the majority of city managers are professional engineers, that Washington, the first non-partisan president, was an engineer, and that Hoover is an engineer.

The daily papers constantly refer to Hoover as being a "business man." He is, and so is every engineer who is the executive head of any organization that produces marketable commodities or services. The Literary Digest has recently called general public attention to Hoover's engineering training as follows:

"Mr. Hoover's riddlesome personality is largely explained, according to one friendly critic, by the simple but usually overlooked fact that he is an engineer, a man of science before everything else. 'He detests the whole breed of politicians with all his heart, as slack-minded, muddle-headed sentimentalists, and therefore anathema to an engineer,' according to this commentator, writing in the New York Globe. Besides, 'he finds unjust criticism from ignorant people very hard to endure, and he shrinks with horror from descending to the dirt and confusion of the arena, as a candidate must do.' Add to all this that he is as proud, shy and sensitive as he is broad-minded and efficient, and you have a character sufficiently complex to explain why not only the political managers, but nearly everybody else, have been set guessing."

The New York Globe is undoubtedly wrong in saying that Hoover "detests the whole breed of politicians."

28 Pages=40 pages

The 28 pages of articles in Engineering and Contracting contain as many words as 40 pages of the size and typography commonly used by other engineering periodicals. Ours is the same size of type and typepage as that of The Literary Digest—easily read, yet giving a large volume of reading matter per page. Our 28 pages of articles would fill 112 pages of the standard 6x9 in. text-book. It would take 10 such books of 580 pages each to hold all the articles printed each year in Engineering and Contracting, to say nothing of our weekly construction news.

Most engineers are strongly altruistic—none more so than Hoover—and an altruist does not detest his fellowman. He may pity an exhibition of ignorance, and he may speak scathingly of a leadership undertaken by men who are too ignorant to be competent leaders; but he does not detest an honest political leader no matter how "slack-minded and muddleheaded" he may be.

In his recent address before the Western Society of Engineers, Hoover said that engineering training leads a man to become a quantitative thinker, and thus to escape many of the false conclusions reached by the ordinary thinker who reasons qualitatively more often than quantitatively. As we have often pointed out, no economic problem can be completely and certainly solved until qualitative words give place to quantitative data. To use a modern engineering expression, economic problems must be finally reduced to equations of cost and of profit. Then, and not till then, does it become possible to solve accurately for a minimum cost or a maximum profit.

Hoover's administration of the food supply during the war was characteristic of the quantitative thinker—the engineer. He secured data as to every kind of food, as to its production, its transportation, and its consumption rates. He guessed at little or nothing, but "got the figures." When he testified the other day before a Senate committee, he "talked in figures," or as the Philadelphia Public Ledger put it, his testimony consisted of "fifteen minutes of hard facts rammed home in the Hooveresque fashion."

Nearly anyone is impressed by quantitative data logically analyzed and clearly presented. But the public is only beginning to realize that problems in political economics differ in no essential respect from problems in business economics and in engineering economics. Hence the surprise with which the public listens to an engineer like Hoover. Evidently the public likes the flavor of figures when spiced with common sense, for Hoover's data and opinions are being quoted in all the newspapers and magazines, today even as they were during the war. This is a good symptom. Perhaps it presages a return to the precedent established by the election of the first non-partisan president, George Washington.

Farmers Organizations Issue a Selfish Political Questionnaire

The National Board of Farm Organizations has submitted a list of 11 questions to all presidential candidates, the evident intention being to oppose any candidate who answers many of them unsatisfactorily. The American Federation of Labor had already announced its determination to oppose any candidate who does not favor certain "labor policies." Now it only remains for the amalgamated "middlemen," the affiliated domestic employes, the associated professional men, and a dozen or so other classes to submit similar questionnaires to prospective candidates. Is this nation moving toward a political war of classes?

The questions submitted by the farmer organizations are, for the most part, filled with evidence of class selfishness. For example, they ask:

> Will you do all that in you lies to secure to all farmers and consumers the full, free and unquestioned right to organize and to purchase and sell co-operatively?

This query is very cleverly worded. There is in existence no law that prevents farmers or others from buying co-operatively. Then why is the word "purchase" inserted in the question? Obviously to conceal the main intent of the question. The Sherman anti-trust law is still in existence, and it hangs as a "heavy, heavy over the heads" of farmers who may organize to sell their product co-operatively. Co-operative selling, in such a case, amounts to monopolistic price fixing. Naturally every intelligent group of producers would like to be free to fix the prices of their own product, provided those from whom they buy are still subject to competition, or have their prices fixed by the government.

If the farmers are to be permitted to "sell co-operatively," they must have their prices regulated by the government. Do they favor that? Not a whit. They rebelled all through the war against government price regulation.

Then they ask another selfish question:

> Will you use your best efforts to secure the payment of the war debt chiefly through a highly graduated income tax or otherwise, by those best able to pay?

Here, again, the phraseology is cleverly designed to "take the curse" of selfishness off the question. They wind up with the words "by those best able to pay," which rings sweetly in the ears, but note the main object. They ask for a "highly graduated income tax." Now it happens that no tax was ever better designed to let the average farmer "off light" than the present highly graduated income tax. Under that tax the average farmer reports but little of what he and his family eat, because he raises most of his own food. He is able also to charge off heavy annual depreciation on all his buildings, animals and equipment.

By contrast consider a city resident working on a salary. He must report practically all his gross income as net income. He has no plant upon which to write off annual depreciation. He raises none of his food, hence is unable to deduct his food from his income as the farmer does automatically by not reporting it as income.

The farmers' questionnaire indicates that they want the packers and railways "regulated," and that they lean toward government ownership of railways, because they ask:

> If at the end of two years of further trial of private ownership the railroads fail to render reasonably satisfactory service to the people, will you then favor opening the railroad question?

The limiting of the railway trial period to two years shows great lack of knowledge of both railway and political economics. But, for that matter, the entire questionnaire betrays so shallow a conception of the nature of economic problems that we doubt whether it will have the approval of farmers as a whole. The questionnaire is said to be the work of one man, C. S. Barrett, president of the national board. The head of an organization frequently does not truly voice the composite opinion of the organization. We hope that this is so in this instance, for it bodes ill for democracy if so large a class as the farmers has decided to secure laws that will discriminate in their favor.

Do Civil Engineering Students Devote Too Much Time to Structural and Hydraulic Subjects

Courses in civil engineering at most engineering colleges give great emphasis to structural and hydraulic engineering—too great, we fear. It is not, we admit, a simple matter to decide correctly what portion of a student's time should be devoted to the study of a given subject. Decisions of this sort are usually arrived at by a "consensus of opinion" of engineering teachers. But a consensus of opinion of practicing engineers might be quite different. Which is entitled to most weight? Is either of them entitled to much weight? Is not the "consensus of opinion," or "hunch method" really unscientific? The problem, in its final analysis, is an economic problem; and economic problems are often incorrectly solved when the "solution" is arrived at by a consensus of opinion, be the opinions those of ever so many authorities.

But, it will be replied, there are some economic problems that must be solved by "the hunch method," in the absence of quantitative data, and this is one of that class of problems. Is it? Who has ever tried to gather data with which to answer the question as to what is the most economic apportionment of an engineering student's time? Until a serious attempt has been made to secure such data, it will scarcely suffice to assert that "the hunch method" is the only one applicable.

We admit that it will be no simple matter to solve this problem by securing quantitative data showing the relative economic merits of different apportionments of the time of engineering students. But we are certain that, until this is done, many errors will be made in the apportionment.

As it now stands, there are two civil engineering subjects that receive a preponderance of attention from civil engineering students, namely structural subjects (including the allied drafting), and hydraulic subjects. Both of these, be it noted, appeal strongly to engineering teachers because they involve a great deal of applied mathematics. It is certainly a delight to most engineers to solve problems with mathematical precision—or with a seeming precision that the use of mathematics implies. But, on the other hand, the majority of problems encountered in civil engineering practice do not lend themselves to the application of any but the simplest mathematics. Why, then, should civil engineering students in the junior and senior years be loaded with such a burden of structural and hydraulic mathematics? An obvious answer is that the application of mathematics is not easily learned after graduation, and that it is therefore wise to insist upon a thorough undergraduate grounding in applied mathematics. This sounds plausible, and it does, in fact, have certain real merit. But has this argument not led to an excessive emphasis being laid upon structural and hydraulic subjects in civil engineering courses? We believe that it has. We think that a questionnaire of practicing civil engineers who graduated as mining engineers would prove the correctness of our contention.

The editor graduated as a mining engineer in 1892 but immediately entered the civil engineering field. In spite of the fact that his course in mining engineering gave him much less training in structural engineering and in hydraulics than was given to civil engineering students (then as well as now), he found it relatively easy to master text books and treatises on structural engineering and hydraulics that he studied after graduation. This experience, he finds, has been similar to that of several other civil engineers who graduated as mining engineers. It is fairly reasonable therefore, to suggest that civil engineering students are, as a rule, required to devote too much time to structural and hydraulic subjects.

A correct answer to this question is to be had only by interrogating practicing civil engineers who did not devote as much time to undergraduate study of structural and hydraulic subjects as is commonly given to those subjects by civil engineering students. It is unscientific to try to solve this economic problem deductively without putting it to the inductive test—the test of experience.

"What Is Economics?"

To the Editor: The writer has read with considerable interest your editorial on "What Is 'Economics'?" in the issue of March 3 commenting on the report of the S. P. E. E. Committee on Economics, and as chairman of that committee and partly responsible for the character of the report, he feels that the views expressed in this editorial should not pass unanswered inasmuch as they are somewhat at variance with those of the committee report.

The writer agrees that some word should be available which could be used to cover the significance attached to "Economics" in your editorial, i. e., to include engineering and industrial management (also domestic and commercial management) as well as political management, but questions the opinion that current usage of the term "Economics" justifies its application in this sense. The word is derived from the Latin **oeconomicus** (or the corresponding Greek **oekonimikos**) meaning orderly or methodical, and in its root meaning, might have had the significance you suggest, but its developed usage has attached a more restricted meaning to it. The word management or administration seems to be the only English word having so general application as to cover this wide range of concepts.

Your editorial says, "It seems to us that a serious mistake was made in defining economics in such a narrow manner as to make it synonymous with political economics." The committee made no attempt to define economics, but merely attempted to use it in the accepted sense and as the word should be interpreted in terms of college curricula. The International Dictionary, probably the most widely accepted authority on the meanings of words, gives the following definition of economics: "The science that investigates the conditions and laws affecting the production, distribution and consumption of wealth, or the means of satisfying human desires; political economy." No other definition is recognized by the authors of that work. Examination of some two dozen standard texts on the subject reveals no appreciable divergence from this conception of the subject on the part of their authors, and an interrogation of several professors of economics yielded a similar result.

It is the writer's opinion, therefore, that the situation is only confused by not recognizing an accepted definition of a term and failure to do so only provokes discussions in which opinions appear to differ when in fact they do not. After a fairly intimate canvass of the practice at various institutions, the committee found that practically every college in the country uses the term in the sense attributed to it by the dictionary and by the committee, including thereunder such matters as corporation finance, labor problems, accounting, banking, and other phases of commerce, and this fact alone would warrant the distinction made by the committee, since the report was to be interpreted in terms of college curricula. Moreover, the committee were of the unanimous opinion that there is very little warrant in current usage for the application of the term economics to the details of a business transaction, or of shop administration, to the design of a structure for minimum cost, to the details of handling labor, etc., and therefore the distinction between "economics" as believed by the committee to be the common acceptation of the term, and "economy of design, construction and operation," which some engineers have rather loosely assumed to be included in the academic significance of the word, was made to clarify nomenclature. "Economy (orderliness) of design," "economy of construction," "economy of operation," etc., are certainly admissible phrases, both from the denotation of the root word and from accepted usage and are really more expressive than is the promiscuous use of the word "economics." This latter word has become almost as threadbare through indiscriminate use as did the word "efficiency" a few years ago. Moreover, as pointed out by the committee, there seems to be so little in common between the theoretical economics as taught in collegiate departments under that caption and the extraneous matters which your editorial apparently would include in the scope of the term, that no advantage is to be gained by grouping them intimately together. These latter subjects are generally taught more or less adequately in connection with engineering courses but are not labeled "economics."

It may happen that in the future some term which will signify **applied economics** may come into use. Engineering is essentially applied science, but need not be limited to applied physical and biological science, e. g., mathematics, physics, chemistry, bacteriology; it might include applied economics and psychology quite as legitimately if these branches of learning should produce principles sufficiently definite and reliable to enable an engineer to apply them with confidence. The "abstract social science" of economics deals with averages, with "movements," "trends," "tendencies," "rises," "waves," "tides," "flowings," "currents," "drifts," etc., etc., whereas the engineer must deal largely with particulars, and while sailing the smooth sea of averages must not allow his barque of professional judgment to be wrecked on the jutting rock, exception. Therefore, while it is eminently desirable for the engineer as an educated man to be able to interpret the significance of the community or social decisions and acts and be guided thereby as a citizen, the evidence was convincing to the Committee of S. P. E. E. that not more than a three hour course could be profitably devoted in an engineering curriculum, contemplating rather immature students, to the "more or less abstract social science" of economics.

C. C. WILLIAMS,
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Lawrence, Kans.

Engineers as Statisticians

To the Editor: I just finished reading the editorial entitled, "A Field for Engineers as Statisticians," published in your issue of March 10th. I agree with you that from a number of standpoints the engineer is peculiarly suited for the collecting of statistical data. This field, however, is especially open to the engineer in so far as the interpreting of this data is concerned.

It must be recognized, however, that all engineers do not make good statisticians. A great many of them are temperamentally unfitted for this class of work. I presume that possibly not more than 10 per cent of our graduates from engineering schools would be temperamentally fitted for this class of work. This number, in the light of the great demand for statisticians, will be inadequate to meet the present need. The solution seems to lie in the possibility of engineers supervising the work of accountants. These accountants would collect the data, leaving the interpretation of it (in part or in whole), to the engineer.

Before we are ready for this step however, these supervising engineers must be brought to a rather different point of view than that which has been characteristic of engineers in general, when in contact with accounting problems.

Many engineers believe that the major and only responsibility which rests upon their shoulders is the completing of the job at hand in as expeditious and safe a manner as is possible under the circumstances. This is, of course, the most important thing an engineer has to do. However, it by no means fulfills all the obligations which an engineer has toward the work at hand. Of considerable importance, is the original estimate. This estimate should form a basis for the accountant in setting up his accounts. The engineer is also obligated to report expenditures in such a manner as to make possible correct bookkeeping.

These two engineering obligations are more and more stepping into the forefront in the minds of men who are financing construction projects. In the last analysis, these obligations should be of vital interest to the engineer. He can only arrive at proper unit cost when care has been taken to report the expense of work done in a correct and all inclusive manner, and when definite and proper record has been made of these expenses.

The oft-repeated criticism that engineers do not know how to estimate is one which should be eliminated as rapidly as possible. Except when face to face with an uncertain market such as prevails at the present, unit costs should be so well established that estimates ought not to vary more than a few per cents from the actual cost of the job when completed. Such large concerns as the Austin Co, have conclusively proved that this is possible. This result can only be obtained, however, when all items are taken into account and the unit costs are established from actual construction experience.

The engineer is apt not to recognize his responsibility toward accounting and statistical data even when these departments are placed under his authority. I believe in a great many instances this is due to lack of proper accounting knowledge on the part of the engineer. A great many engineers do not know the simplest rudiments of correct accounting. They are, therefore, unable to criticise the acts of their accounting subordinates from the standpoint of an actual working knowledge of the accounting at hand. The accountant on the other hand, does not have the engineering view point and many times innocently draws up his accounts in such a manner as to falsify the true expenditure and make the obtaining of correct unit costs almost impossible.

These difficulties can only be eliminated either by giving the accountant something of the engineer's viewpoint or by giving the engineer the accountant's viewpoint. You rarely find the accountant in authority and therefore, the understanding of the other's problem should be on the part of the engineer, who should be thoroughly familiar with the fundamentals of good accounting.

Our engineering schools have an obligation which, I am afraid, a good many of them have not seen. Every engineering graduate should have at least a foundation in good business methods. This would involve instruction in such courses as accounting, contracts, and various incidental subjects to broaden the young engineer from a business standpoint. Most engineers learn these phases of business through actual experience after graduation. These experiences are often based upon the practice of the particular concern by whom they are employed. This means a limited point of view where they should have a broad foundation. It is my experience that engineers are rather inclined to look down upon accounting and regard it as none of their particular concern. It can, however, be adapted to meet a very present and critical need. It is a handy tool for the engineer if used with knowledge and precision. It can solve the unit cost problem and practically eliminate the criticism of poor estimating on the part of the engineer.

As a profession we should not eliminate from our minds the necessity of completing the work as promptly, safely and as beautifully as possible, but neither should we forget the importance of properly accounting for all the work done.

F. H. PLAISTED,
Cincinnati, O. Office Engineer, C. C. C. & St. L. Ry.

Wind Bracing in the Steel Frames of Office Buildings

By W. M. WILSON and F. E. RICHART.

The modern office building consists of a steel frame supporting masonry walls. The wind on the side of the building produces a pressure on the curtain wall, and this pressure is transmitted by the wall to the steel frame. It is customary to assume that the curtain wall delivers the wind pressure to the frame at the floor levels. This being true, the loads due to the wind pressure consist of a concentrated force at each floor. The problem of the designer is to so construct the steel frame that it can resist these horizontal forces.

Any story of a building is subjected to a horizontal shearing force equal to the total wind pressure upon the building above the story in question. If it were permissible to place diagonal bracing between the columns, this horizontal shear would not cause any difficulty in design. However, buildings of this type usually occur where space and lighting are at a premium, so that the structural engineers are seldom permitted to put diagonal bracing between the columns in either interior or exterior bents. It is, therefore, customary to provide joints in certain bents, thus making the rectangular frames capable of resisting horizontal shear. To understand how these frames function, consider the frame represented in Fig. 1. The connections of this frame are hinges, and if the frame is subjected to a shear, as shown in the figure, these hinges permit the frame to collapse. The frame in Fig. 2, however, has connections at the corners which are rigid. If this frame is subjected to shear, as shown in the sketch, instead of the frame collapsing, the rigidity of connections will restrain the ends of the columns and girders so that the frame will retain approximately its original shape. The bent of an office building which is designed to resist wind pressure is made up of a number of frames similar to the one represented in Fig. 2. and the horizontal shear in a story of a building is resisted by the rectangular frames.

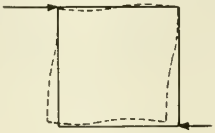


Fig. 1.

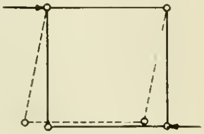


Fig. 2.

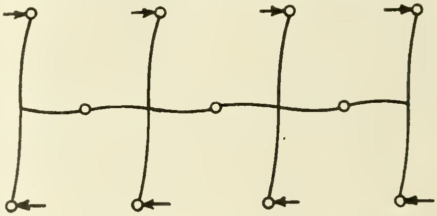


Fig. 3.

From an examination of Fig. 2, it is apparent that the axes of these columns are compound curves, and that there is a reversal of curvature some place between the top and the bottom. If the top and the bottom are restrained equally, the point where the curvature changes sign, or the point of contraflexure, is half way between the top and the bottom of the column. If the degrees of restraint at the top and the bottom of the column are not equal, the point of contraflexure will be shifted either upward or downward. Likewise, the axes of the girders are compound curves having points of contraflexure some place between the adjacent columns.

The point of contraflexure, or the point where the curve changes sign, is a point of zero moment. Therefore, if we introduce hinges at the points of contraflexure in the columns and girders, a story of the frame of an office building may be represented by the sketch shown in Fig. 3. From this figure, it is apparent that the joint connecting girders to a column is subjected to a turning moment due to the shear in the columns. This turning moment is resisted by the girders and the shear in the girders depends upon the magnitude of the moment to be resisted. If the locations of the points of contraflexure of the columns and girders are known, and if the shears upon the columns are known, the moment in the columns and girders and the shear in the girders can be determined. Therefore, the problem of determining the wind stresses in the frame of an office building consists of first determining the distribution of the shear in a story among the columns and then locating the points of contraflexure in the girders and columns.

If all the columns of a story have the same degrees of restraint at the ends, the distribution of the total shear among the columns would be directly proportional to the moments of inertia of the sections of the respective columns. In the case of the outside column, there is only one girder resisting the rotation of the connection caused by the column; whereas with an interior column, there are two girders resisting the rotation caused by the column. It is, therefore, evident that interior and exterior columns do not have the same degrees of restraint; and, therefore, the shear on a story is not equally distributed among the columns. Furthermore, the degree of restraint at the end of a column depends upon the stiffness of the members intersecting at the end in question. As columns vary in section, and therefore, in stiffness, and as all girders are not of equal section, the degree of restraint at the top and the bottom of a story of a column may not necessarily be equal. Therefore, the location of the point of contraflexure of a column is uncertain. In conclusion, therefore, it is apparent that both the distribution of the shear and the locations of the points of contraflexure are difficult to determine. They depend upon a number of very complicated quantities, and their exact determination is impossible.

In the absence of an exact method for determining the wind stresses in an office building, a number of approximate methods have been suggested. Three of these methods, referred to below as Methods I, II, and III, were described by Mr. R. Fleming in the "Engineering News" of March 13, 1913; and another method, referred to below as Method IV, was described by Professor Albert Smith in the "Journal, Western Society of Engineers," Vol. 20, No. 4, page 341. These methods are based upon the following assumptions:

Assumptions in Method I:

1. A bent of a frame acts as a cantilever.
2. The point of contraflexure of each column is at mid-height of the story.
3. The point of contraflexure of each girder is at its mid-length.
4. The direct stress in a column is directly proportional to the distance from the column to the neutral axis of the bent.

Assumptions in Method II:

1. A bent of a frame acts as a series of portals.
2. The point of contraflexure of each column is at mid-height of the story.
3. The shear is the same on all columns of a story.
4. Each pair of adjacent columns of a bent acts as a portal, and each interior column is a member of two adjacent portals. The direct stress in an interior column, when the column is considered as a member of the portal on one side, is of opposite sign from the direct stress in the same column when considered as a member of the portal on the opposite side, and the resultant direct stress is equal to zero.

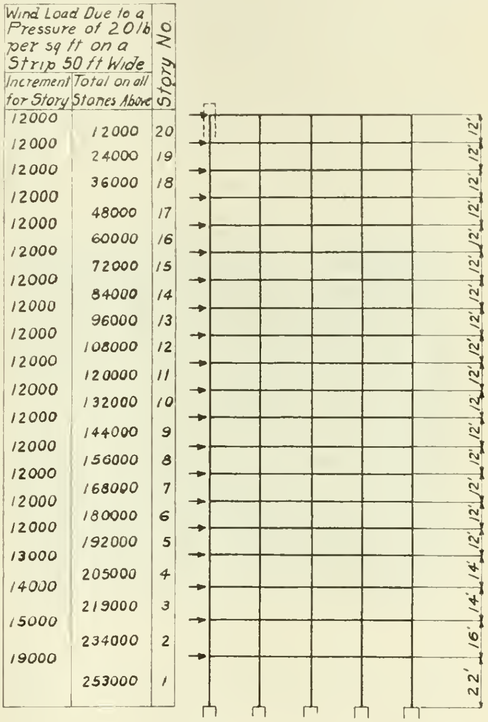
Assumptions in Method III:

1. A bent of a frame acts as a continuous portal.
2. The point of contraflexure of each column is at mid-height of the story.
3. The direct stress in a column is directly proportional to the distance from the column to the neutral axis of the bent.
4. The shear is the same on all columns of a story.

Assumptions in Method IV:

1. The point of contraflexure of each column is at the mid-height of the story.
2. The point of contraflexure of each girder is at its mid-length.
3. The shears on the interior columns are equal and the shear on each exterior column is equal to one-half of the shear on an interior column.

If the assumptions upon which any one of these methods are based are accepted, the stresses can be determined. Moreover, when the assumptions of any one of these methods are considered by themselves, they appear reasonable. It is an unfortunate fact, however, that if the four methods are applied to the same frame, the results obtained by the four methods are radically different, showing that some, if not all, of the methods are grossly inaccurate. In the absence of any accurate standard by means of which to compare these methods, it was impossible to determine which, if any, were accurate enough for purposes of design. In order to establish a standard of accuracy the stresses in a 20-story office building were determined by the slope deflection method. (Bulletin No. 80, Engineering Experiment Station, University of Illinois, by W. M. Wilson and G. A. Maney.) In the application of the slope deflection method the following assumptions were made:



Wind Load Due to a Pressure of 20 lb per sq ft on a Strip 50 ft Wide: Increment for Story	Total on all Stories Above	Story No.
12000	12000	20
12000	24000	19
12000	36000	18
12000	48000	17
12000	60000	16
12000	72000	15
12000	84000	14
12000	96000	13
12000	108000	12
12000	120000	11
12000	132000	10
12000	144000	9
12000	156000	8
12000	168000	7
12000	180000	6
12000	192000	5
13000	205000	4
14000	219000	3
15000	234000	2
19000	253000	1

Fig. 4.

1. The connections between the columns and girders are perfectly rigid.
2. The change in length of a member due to direct stress is equal to zero.
3. The length of a girder is the distance between the neutral axes of the columns which it connects, and the length of a column is the distance between the neutral axes of the girders which it connects.
4. The deflection of a member due to internal shearing stresses is equal to zero.
5. The wind load is resisted entirely by the steel frame.

Experiments show that errors resulting from the inaccuracy of Assumptions 1 and 3 may be neglected. ("Tests to Determine the Rigidity of Riveted Joints of Steel Structures," by W. M. Wilson and H. F. Moore, Bulletin No. 104, Engineering Experiment Station, University of Illinois.) Mathematical analyses show that for frames of the proportion usually used in office buildings, the errors due to Assumptions 2 and 4 are negligible. Aside from these assumptions, the method used in Bulletin No. 80 may be considered accurate, inasmuch as it took into consideration the relative stiffness of the members and the degree of restraint at the ends of the members. This analysis, therefore, affords a standard by means of which the accuracy of the four approximate methods can be measured. Upon comparing the results of the accurate and the approximate methods, it was found that Methods I and IV are accurate enough for purposes of design, but that Methods II and III are so inaccurate that they never should be used. Of the two approximate methods which were found to be satisfactory, Method IV is very much simpler than Method I. Moreover, with Method IV, the moments at the ends of all girders at any floor of the bent are equal and, therefore, the connections at the ends of these girders may be identical. The writers recommend that Method IV be used in designing the wind bracing of office buildings.

The left-hand portion of Fig. 4 shows a convenient way of tabulating the data to be used in computing wind stresses. The calculations themselves may be tabulated as represented in Table I. In this table the quantities on columns 3 and 4 are read directly from Fig. 4. The shears on all interior columns of a story are assumed to be equal and the shear on an exterior column is assumed to be one-half the shear on an interior column. Therefore the shear on an interior column, for the bent represented by Fig. 4, is one-fourth the total shear. In general, the shear on an exterior column is the total shear divided by one less than the total number of columns in the bent. The quantities in column 6 of Table I are, therefore, obtained by dividing the data in column 4 by four. The quantities in column 5 are obtained by dividing the quantities in column 6 by two. The quantities in columns 7 and 8 are obtained by multiplying the quantities in columns 5 and 6 by the quantities in column 3. The quantities in column 9 are obtained from the quantities in column 7 as follows. The moment in the girders in the 6th floor is the sum of the moments in the exterior columns (column 7 of Table I) of the 5th and 6th stories. Likewise the moment in the girders in the 5th floor is the sum of the moments in the exterior columns of the 4th and 5th stories. It is to be remembered that all of the girders in a given floor are subjected to the same moment due to the wind pressure.

To illustrate the application of Method IV, the following numerical problem is presented: Fig. 4 represents a bent of an office building. The distance between bents braced to resist wind pressure is 50 ft. The pressure to be resisted by this bent is, therefore, the wind pressure on a vertical strip of wall 50 ft. wide. Following the building ordinances of the city of Chicago the building should be designed to resist a wind pressure of 20 lb. per square foot. The wind pressure on the bent will, therefore, be 50 x 20 or 1000 lb. per vertical foot. The force which is applied at each floor level consists of one-half of the pressure on the curtain wall of the story above and one-half of the pressure upon the curtain wall in the story below the floor in question. If, therefore, the 5th story is 12 ft. high and the 4th story is 14 ft. high, the wind pressure at the 5th floor will be the sum of one-half of 12 plus one-half of 14 multiplied by 1000, or 13,000 lb. In the same way the load at each floor may be determined. By making the calculations as indicated in Table I the determination of the wind stresses is a very simple matter.

Although the method which has been recommended for determining the wind stresses in a building is accurate enough for purposes of design for ordinary building frames, any special features of the frame, such as the discontinuance of a column, large differences in column section, or the omission of a girder requires special consideration. Furthermore, if the wind bracing in a bent is not continuous, care must be exercised in the interpretation of the terms "interior" and "exterior" columns. In the sense in which the terms are used in the application of Method IV, an exterior column is a column which has a moment-resisting girder on one side only; whereas, an interior column is a column having a moment-resisting girder in the plane of the bent of the column on both sides.

TABLE I—WIND STRESS CALCULATIONS.

Story No. (1)	Floor No. (2)	One Half Story Height Inches (3)	Shear in 1000 lb Total in Story (4)	Shear in 1000 lb Exterior Column (5)	Shear in 1000 lb Interior Column (6)	Moment in 1000 in lb Exterior Column (7)	Moment in 1000 in lb Interior Column (8)	Moment in 1000 in lb Girder (9)
6		72	180	22.5	45.0	1620	3240	
	6							3350
5		72	192	24.0	48 0	1730	3460	
	5							3880
4		84	205	25.6	51.3	2150	4300	
	4							4450
3		84	219	27.4	548	2300	4600	
	3							5105
2		96	234	29 3	58.5	2805	5610	
	2							6975
1		132	253	31.6	63.2	4170	8340	
	1							

Why House Building Must Increase

By WHARTON CLAY.

Commissioner, Associated Metal Lath Manufacturers, Inc.

The stability of the building industry is based, like every other industry, upon supply and demand. The increasing population demands more dwellings, and building will, unquestionably, continue.

1918 saw only 20,000 new houses built. There should have been 20 times that many.

1919 was a bit better with 70,000 dwellings completed according to the estimates by the U. S. Housing Corporation. But still the increase in population is far outstripping the building program for new houses. While in 1890, an average of 110.5 families occupied each 100 homes, today that figure has mounted to 121 families for every 100 dwellings. Hence, the present acute congestion.

With a conservative estimate of 27,900,000 families in 1925 the great housing shortage will continue unless building in all parts of the country increases to an extent unparalleled in the history of the construction business.

If only the current number of homes are constructed each year for the next five years 409,500 homes must be built, and the congestion will reach 129.6 families per hundred homes or 2 families in every fourth house.

Merely to keep up with the increasing number of families and in no way alleviate the present congestion 2,139,000 homes have to be constructed before 1926, while a return to the prewar conditions of 115 families per 100 homes means the building of 3,340,000 dwellings in that period. When it is considered that in a town of 25,000 this construction program means 475 and 750 homes in 5 years respectively, the stability of the building industry becomes apparent.

The following table shows how, for the last three decades, the number of families in the country has exceeded the number of dwellings:

	Families	Dwellings
1890	12,690,152	11,483,318
1900	16,187,715	14,430,145
1910	20,255,555	17,895,845
1915	22,786,499	19,853,517
1916	23,292,887	20,263,051
1917	23,799,275	20,672,051
1918	24,305,662	20,808,562
1919	24,872,051	20,829,039
1920	25,319,443	20,900,000

Design and Construction of Bridges by Architects.—The Council of the American Institute of Consulting Engineers, Inc., on Feb. 5 adopted the following resolution:

Whereas: It is reported to the Council of the American Institute of Consulting Engineers that responsibility for the design and construction of certain important bridges has recently been intrusted to firms of architects; and

Whereas: In the construction of bridges of any type, and for any purpose the engineering problems are of vital and first importance in providing safety, adaptability and durability of the structures produced; and

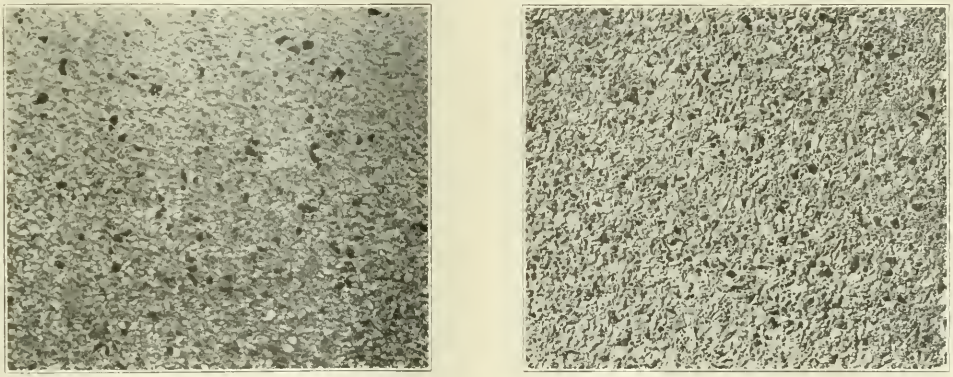
Whereas: The external architectural treatment and decorative effect is secondary in importance to the engineering design; therefore, be it

Resolved, That the Council of the American Institute of Consulting Engineers condemns and protests against public bodies entrusting the responsibility for the design or production of such important engineering structures to professional men whose training and practice is in a wholly different field, and who must, therefore, delegate to subordinates the solution of the fundamental problems of primary and vital importance. The Council condemns a division of the responsibility which will inevitably result by departing from ordinary procedure, and urges that no further work of the kind be entrusted to any except specialized engineers of acknowledged standing. The Council recommends, however, that in the case of monumental structures, the decorative effect secured by architectural treatment shall be considered by specialists engaged for that specific purpose.

New Developments in Surface Treated Concrete and Stucco

New developments in the treatment of concrete surfaces, the success of which is due largely to scientific studies of the behavior of combinations of various sized particles, and the development of a technique adequate for the molding of these combinations of particles in any desired form and place, were described by J. C. Pearson, of the U. S. Bureau of Standards, and J. J. Earley, Sculptor, Washington, D. C., in a paper presented last month at the annual convention of the American Concrete Institute. The following abstract of the paper is taken from the Vol. 16, 1920, Copyright Proceedings of the Institute.

Studies of the experimental stucco panels at the Bureau of Standards led to the general conclusion that by adherence to well established practice, structurally sound and durable stucco could be secured, but that a great deal could be, or ought to be, done to improve its appearance. Crazing and map cracking are common to most stuccos, and are especially objectionable on surfaces of fine texture; the monotony of the cold grey cement color is objectionable, and is only partially relieved by the use of white cement and mortar colors; and finally the muddy appearance (due to cement, or cement and pigment, being too much in evidence) is objectionable from an artistic standpoint.



Concrete Surfaces Constructed by Earley-Pearson Methods.

Consideration of these matters suggested at once the use of less cement, and it became evident that by efforts in this direction improvement in appearance might be obtained. The apparently insurmountable obstacle to this departure from usual practice was, of course, the lack of plasticity in the leaner mixtures. Various methods of overcoming this difficulty were considered, and some experiments were made which indicated that a real improvement might be obtained by substituting fine inert material for a portion of the cement.

The easiest way to accomplish this result seemed to be by using blended cements, that is, normal cements ground with a certain percentage of sand, stone-screenings, or other suitable materials. These experiments were never carried very far, however, for it did not seem possible that any method which might be devised for retaining plasticity could bring about the desired result, viz., the elimination of all the objectionable features mentioned above.

Serious as was this lack of plasticity in the lean stucco mixtures, it was, after all, something that could be overcome by work. This was demonstrated by the fact that mixtures as lean as 1 part cement to 6 parts of stone screenings were applied on some of the Bureau of Standards panels, with excellent results. But the improvement in these panels as compared with some of the easier working combinations did not seem great enough to justify the increased cost of application. The question finally arose whether by careful attention to gradation of the aggregate this improvement in appearance might not be so enhanced that the cost would be a secondary consideration.

This idea came from the fact that Mr. Earley had succeeded in making complicated casts of concrete from specially graded aggregates in such manner that a very large percentage of the area of the treated surface (first wire brushed and then washed) was aggregate, and a very small percentage cement. Possibly due in part to the higher reflecting power of the surfaces of the exposed aggregates, the color of the concrete surfaces thus produced was determined almost wholly by the color of the aggregates, and only very slightly affected by the cement itself. A most convincing demonstration of this fact was obtained by constructing two concrete slabs containing exactly the same proportions of specially graded aggregate, the one being mixed with grey cement, the other with white cement. After the surface treatment of brushing and washing had been applied, only an expert could have determined which slab contained the grey cement and which the white.

This method of obtaining permanent and very pleasing colors in concrete surfaces is such an important item in the development of the processes here described, that it is worthy of fuller explanation. Before color in concrete surfaces can be under artistic control, a technique must be developed which has for its medium the elements of the concrete itself. Although in problems involving appearance aggregate is by reason of its greater bulk the major element, and cement the minor, it is, neverthless, the color of the cement which is the natural color of normal concrete.

The reason for this is that the cement is finely ground and deposits itself, paint-like, over the surfaces of the aggregates and colors the whole mass. If, therefore, concrete is to receive its color from the cement paste, variation must be obtained by the addition of pigments to the cement following the well established practice of mixing paints; but if the aggregate is to be the source of color, the concrete must be so designed and manipulated as to deposit in the greatest possible amount of aggregate.

Any great degree of success can hardly be expected in coloring concrete through the cement. The choice of colors is restricted by chemical reaction with the cement which causes them to fade or change; depth of color is restricted by strength requirements of the concrete which limits very closely the amount of pigment which may be added to the cement. Therefore with the choice of color limited by one requirement and the depth of color by another, the cement itself must remain dominant.

On the other hand, in coloring concrete through the aggregate all such restrictions are removed, and colors may be obtained from white to black, through all the range of possible aggregates.

An examination of drawings done in hard pastelles and of paintings of the impressionist school suggests a technique in coloring which is peculiarly adaptable to the coloring of concrete by means of the aggregate. In the pastelles tones are produced by hatching and cross-hatching with lines of pure color without blending on the surface of the drawing, in the paintings by spotting with pure colors one beside the other and without blending. In both cases the tones are effected by the blending of the light rays reflected from the picture to the observer. Wonderful depth and clarity of tone are characteristics of this school of coloring, and in it are to be found a great deal of exact knowledge and valuable precedent.

When this knowledge is translated in terms of concrete aggregates, it is obvious that if the aggregates are carefully selected and carefully placed, all the elements are present for the successful coloring of concrete surfaces. The results obtained in practice bear out the theory given above, and there is every reason to believe that the aggregate is the proper source of color for concrete.

Hence it was a most important conception that a similar result might be obtained with stucco. The success of this depended, first, upon securing a suitable gradation of the stucco aggregate, and second, upon being able to apply such a mixture, once it were satisfactorily compounded. It was known at the outset that these mixtures would be harsh, therefore plasticity no longer played any part in the calculations.

The laboratory program was fairly simple. The plan consisted simply in working first with concrete mixes in miniature, in which the sizes of cement particles, sand particles and coarse aggregate particles were reduced from the normal sizes in the ratio of about 1:10, this being taken as the approximate ratio of the size of particles passing a No. 8 sieve to pebbles 1 in. in diameter. It was assumed that the density of such mixes would depend mainly on relative sizes of the component particles, with due allowance for the water content.

If these mixes appeared to be satisfactory for the purpose, it was assumed that any reduction within the 1:10 ratio would also be satisfactory, and the actual reduction to be employed in compounding any given stucco mixture of this type would be as slight as the requirements of texture and the difficulties of application would permit. To make a long story short, these experiments in the laboratory with the miniature concretes were very successful.

Not the least important part of the laboratory work was the microscopic examination of the structures of these little concretes, which yielded many valuable suggestions for the gradation in size of particles, and for the proper proportions of the various sizes, to yield the desired effects in the treated surfaces.

The first attempt to apply the new product to a vertical wall was not wholly discouraging. Small areas were treated successfully, and eventually a portion of one of the new laboratories of the Bureau of Standards was coated with the exposed aggregate stucco. This example, while it is not as free from imperfections as the more recent work, has attracted most favorable notice.

Fortunately, the mechanics who were selected for this work developed a real interest in the new type of finish, and subsequently a pride in the results of their work, which made for very rapid progress in the development of the methods of application and treatment. New requirements in thoroughness of mixing, consistency, and control of the absorption of the undercoats were met, and other improvemnts in the general process were gradually introduced as essential parts of the routine. Not all of the problems have been solved, but there has been very gratifying progress in the comparatively short time that the new stucco has been applied commercially.

Comparative Building Figures. Although the building figures for 1919 show a substantial increase in values over previous years, Babson's Statistical Index points out that, making allowances for the increase in building costs, including labor, which have arisen on an average of 80 to 90 per cent since 1914, the actual volume of building for December, 1919, amounts to about the same as in December, 1912, or December, 1913. For the past 11 years, the annual building figures for 120 identical cities are as follows:

1909	$ 888,114,741	1915	$ 763,343,811
1910	846,991,622	1916	919,435,203
1911	824,117,884	1917	633,483,313
1912	879,094,308	1918	372,793,978
1913	814,509,360	1919	1,170,773,197
1914	728,801,072		

The Architectural Profession in the Present Day*

By RICHARD WALLACE TUDOR

It must be evident to anyone who is at all familiar with the practice of architecture and that background of experience and formal education which goes into the development of the architect, that a fairly clean-cut divergence in interest has arisen between the so-called "principles" of architectural practice and the so-called "principles" underlying modern business enterprise. It is likewise evident that out of this divergence in interest something closely akin to a conflict has arisen.

No one can very well deny that the inquiry which is now being conducted by the architects here and in other countries with respect to their status and their business methods, arises out of a realization that the position of the profession has become somewhat precarious. Something in the nature of a doubt as to the future of the profession has come to occupy the place of a certain assurance which prevailed in the profession but a few years before the war.

Before the War.—In the days immediately preceding the war, as now, a vast number of buildings came into existence without the aid of the architectural profession. Some estimates place the volume of building erected by builders and business men without the services of any one especially trained by experience or otherwise to perform that particular kind of service, as high as 90 per cent. The exact percentage erected in recent years without the aid of the architectural profession, however, has no material bearing upon the point in question. The number of buildings so erected is notorious; this statement is borne out by an examination of the kind and quality of that great mass of structure, both urban and rural, which make up our material environment.

During that period immediately preceding the war, the profession was young, relatively speaking, and was primarily engaged in formulating its canons of ethics, schedule of charges, and methods of procedure, both as regards individual practice and the Institute. It was particularly intent upon more firmly establishing its status in line with a rather definite preconceived concept of what constitutes architecture and the services of the architect. Thus intent upon, and one might say exclusively engaged with, the problem of more firmly establishing its status in rigid conformity to a concept of a bygone age, the profession, as represented by the Institute, paid relatively little heed to the fact that in failing to provide architectural service in connection with all buildings, it was failing as a profession to meet the problem at hand.

Building Without Architects.—That the majority of all structures should be built without architectural service was accepted "as a matter of course." All of those secondary structures in the great mass of building, erected by speculative builders, small contractors, and business men, were not deemed worthy of serious consideration; so nothing was done about it.

But it appears, from no more than a casual examination of buildings erected through such agencies, that enterprise of this nature was highly profitable. Business men are particularly observing where possible profits are in view, and the fact that speculative building seemed highly profitable was by them observed, particularly by those who "operate" in the larger fields of business enterprise. As a result, in the course of time, building operations of a speculative nature, instead of being confined to the small speculative builder and small promoter, came to be regarded as a legitimate and profitable field for the larger and more aggressive forms of business enterprise.

The Present Drift.—And so, while the situation is quite similar today, in that the vast majority of buildings are now erected without the services of the architect, there is a difference. The larger and more aggressive business organizations are gradually taking over not only the operation of financing and constructing, but also are performing the architectural services involved. Nor do they confine themselves to the small field previously occupied by the speculative builder. They are already entering a field previously marked off by the architectural profession as its own sacred area.

While it may not be quite accurate or fair to say that the situation thus briefly suggested is what really animates the present inquiry into the affairs of the profession, as referred to above, it is probably fair to say that it was no less than chief among the conditions which animated the inquiry, whether openly acknowledged or not.

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*From the Journal of The American Institute of Architects

Therefore it would seem that a most pertinent line of inquiry to follow would be that which might possibly throw some light upon what is most likely to be the outcome of the present drift of affairs. Of course, anything in the nature of final conclusions from such an inquiry would be largely in the nature of a guess; on the other hand, if an inquiry were properly conducted and all matters of importance were taken into account, the conclusions need not necessarily shape themselves into the form of a blind guess, as seems to be characteristic of the present state of the inquiry.

The Modern Kings.—It is not to be wondered at that the architect of today stands somewhat bewildered in a world dominated by machine technology, business enterprise, and capitalistic endeavor, for he occupies a curious position—a conspicuously curious position.

"The material framework of modern civilization is the industrial system, and the directing force which animates this framework is business enterprise. To a greater extent than any other known phase of culture, modern Christendom takes its complexion from its economic organization. This modern economic organization is the 'Capitalistic System' or 'Modern Industrial System' so called. Its characteristic features and, at the same time, the forces by virtue of which it dominates modern culture are the machine process and investment for a profit. . . . The business man, especially the business man of wide experience, has become a controlling force in industry, because, through the mechanism of investments and markets, he controls the plants and the processes and these set the pace and determine the direction of movements for the rest. . . . Upon him and his fortune centers the abiding interest of civilized mankind. . . . For a theoretical inquiry into the course of civilized life as it runs in the immediate present, therefore, and as it is running into the proximate future, no single faction in the cultural situation has an importance equal to the business man and his work."†

In this framework of modern civilization does the architect undersand the conflict as regards the production of buildings as conceived by him, on the one hand, and by business enterprise on the other? Do architects who give direction to those formulated professional statements that emanate from architectural societies, and who give direction to architectural education, understand what really dominates and gives direction to the activities of modern society? Is there not on their part a holding back, a very definite tendency to cling to a certain point of view with respect to what constitutes architecture and to methods of building which prevailed some centuries past? To the onlooker it would appear that the profession now occupies a position which might be expressed as the third-line trenches in the conflict which has been growing for a century or more between "modern business enterprise" and the instinct of workmanship. The architectural profession is the last force left in the trenches. Its bewilderment at this present juncture is very largely due to conditions which have developed in the very recent past, and which find a more complete expression in the present.

Speeding Up.—About a score of years ago, if we may judge by the attitude of the profession at that time, something like an understanding of the functions of the profession and the services it could properly perform was slowly developing; a so-called "better taste" in building was to be observed. After a long period of remarkably ugly and stupid building, it appeared that architecture was to take on a better character; the profession was to be recognized and recompensed. That was the period of rapid business expansion in America—the formation of great combinations and the wholesale production of things. It was at this juncture that the general contractors stepped in and took over a large part of the work which had been formerly performed by the architect as a part of the building service be rendered. Relatively, these were times of great prosperity and equally great optimism; the architect was swept along with the spirit of modern business enterprise.

But further and important changes have taken place within this brief period of the recent past, and today the architect finds that that beneficent spirit of business enterprise, upon which he looked with favor and to which he looked to carry him along toward more magnificent architectural achievements, bids fair to be his undoing. Within a few years, from a position of relative security and a relatively beneficent rating which was coming to be assigned to his services, he suddenly awakens to a realization that his hopes are possibly to be rudely shattered by the ever-broadening activities of business men who are aggressively engaged in the modern business-like activity of gradually taking over the architect's business as a part of the act of gaining control over all production. In the meantime the architect and his abilities are being made use of as mere adjuncts of business in this work of relieving him of his means of livelihood. This act is in direct line with the general policies of business; it expresses the drift of things in modern times and is parallel with that act of business which once stepped in and took over, in a wholesale way, the work of the craftsman.

Art or Business?—Realizing vaguely that some sort of action should be taken by the profession if architects are to continue to function in the accepted meaning of the term, the organized profession institutes investigation of itself, its organization, and its activities. It debates the question: Is architecture an art or a business? It wisely suggests reforms within its own body and advocates campaigns of propaganda and advertising to stimulate public appreciation of both art and the value of architectural services by members of the professional body.

From the debates, it does not appear that there is other than confusion in the minds of the profession in general. Above all it does not appear that any need whatsoever of reform in practice is deemed important to a large and influential group of architects, particularly those who have come into a remunerative practice. And among the majority who advocate changes, those seriously considered relate almost exclusively to matters of little importance.

If one may generalize in a field where the discussion revolves around details of organization and practice, the opinion prevails that the results desired may be achieved most readily (and with the least effort) by propaganda and advertising aimed at bringing the public to that point of view which reveals the nature (and the value) of art and architecture as it obtains in the academic atmosphere and sheltered regions of the studio and in the mind of the old-school practitioner who has built a remunerative practice by catering to the pecuniary canons of taste established by modern society.

This prevailing attitude on the part of the profession, particularly among those who are generally rated as "well established" fails to take into account two extremely important matters. It is assumed that the point of view of the profession will be accepted by the public once the matter has been fully explained; that with the value of art and architecture once demonstrated, and the peculiar service of the architect made perfectly clear, modern business enterprise will make an exception in the case of art, architecture, and the architect, and will stand off. Now it happens that an idea or a program to be accepted generally must be one which coincides with what the public deems of prime interest to it. Any appeal to business interest must be made largely upon the ground that the interest of business enterprise will be the better served; in the same way, it must be made clear to the common man that he has something to gain by responding.

Building for Profits and Wages. What may be termed the architect's point of view as to what constitutes architecture, has come down from certain historic periods of generally acknowledged architectural excellence in which the forces that actuated building were of a cultural nature for which we find no counterpart in the present day. Therefore, any considerable emphasis upon the value of tradition as to "forms" or manner of building is not at all likely to be understood by those engaged in building for speculative profit or for wages. That the emphasis placed upon forms by architects is not understood is notorious, of course. To individuals engaged in building enterprises, both directors and workmen, the high rating assigned by architects to certain forms and certain methods of construction appears utterly beside the point, for neither the directors of business for profit nor the marksman engaged in building for wages can see precisely in what way he is to be benefited by a general adoption of the kind of architecture which is held up to him for his admiration. And as a matter of fact, that which the profession is always so insistent upon emphasizing as of such high esthetic value, particularly that work which is of a grandiose nature—exhibitions of the work of our schools of architecture—is quite beside the point. It can have no possible interest for those occupied in business enterprise for profit, or the man working for wages. It is not easy for either to see precisely what is to be gained by more of it. Architecture of the sort emphasized does not, as a general condition, point the way toward greater profit from the viewpoint of business enterprise; and, so far as the common man is concerned, all of it is quite outside his field of contact in so far as it relates to the affairs of his life. Any hope that the spirit of business enterprise will stand off, that it will not seek completely to dominate and control the practice of architecture is a forlorn hope, for it must be apparent to anyone who has observed the drift of things in the recent past that there is not the slightest reason for assuming that the practice of architecture will stand immune. It is the aim of business enterprise to dominate and control all production, and so why should it be assumed that the production of buildings may be carried on in the immediate future upon other lines than those laid down by the forces which are gradually gaining control over all production?

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† "The Theory of Business Enterprise," by Thorstein Veblen, Charles Scribner's Sons, 1919.

Business and Art. But one may insist that art and architecture are matters which fall outside the realm of business enterprise; that business enterprise cannot produce art. Architecture is art and therefore why worry? Here is revealed how we fail to come to grips with the actual situation. Modern business enterprise, in control of modern machine industry, aiming always at quantity production, has not been able as yet to produce things of that quality of design and finish which are so highly prized by those who can afford to buy whatever carries the mark of these qualities associated with the architecture of the past and of handicraft industry. And since those products of creative endeavor which occasionally emerge are bound to enter the market in competition with the salable wares produced by strictly business enterprise, it naturally follows that, from the viewpoint of modern business enterprise, the situation may be most advantageously treated by killing this competition.

Now it happens that buildings fall well within the category of the products of modern business enterprise, and hence it is that the architect is confronted with a very strong and aggressive competitor. The outlook for architecture, using the term in its generally accepted meaning, is not bright. What character of buildings would result from a condition in which the design and construction was wholly within the control of modern business enterprise is not easy to forecast. It may soon be possible to gather general ideas under this head through a survey of the buildings which comprise those areas given over to industry, and business in which no "architectural" influence may be said to have penetrated. What kind of architecture might be developed by modern business enterprise were it to take over the function of the architect, does not fall strictly within the field of this inquiry, and is queried merely in passing.

The Future. The architect may attempt to hold firmly the position which he now occupies, in which case he is more than likely to fail, particularly if he holds to that group of ideas that has worked for the establishment of the position he now holds. Not only is he likely to fail so to hold his position, but he is likely never to have anything to do with that great class of buildings which now come into being very largely without the aid of his services. All this is likely unless—and this of course is the vital question to consider—a new grouping of forces should come about in such a way as to seriously modify the current of modern business enterprise as it runs, particularly if that modification should be in the nature of changing the animating forces of business enterprise from investment for profit and the charging of all that the traffic will bear.

It would be interesting and undoubtedly profitable to continue this line of inquiry a step beyond. It might possibly reveal that the major matter, which should now be considered by those engaged in the discussion of the internal affairs of the architectural profession, would be that which had to do primarily with the working of a change in our economic institutions.

The Case of Initial Tension

By R. FLEMING,

American Bridge Co., New York City.

Some opinions recently expressed to the writer regarding initial tension are so at variance with his own, that he has reviewed the subject, one outcome of which is this article.

Bolts and Rivets.

A question that probably arose soon after the invention of the steam engine was, "Suppose the bolts securing the head to the cylinder of a steam engine to be initially drawn up under a combined tension that exceeds that of the steam-pressure on the head; will this initial tension on the bolts be increased by the steam-pressure, when steam is admitted to the cylinder, or will it not?" It might be thought that so important a question would be settled at an early date. Yet Carl G. Barth in an article in the Home Study Magazine, November, 1897, tells of his finding the designers and draftsmen of a great industrial corporation divided into opposing parties on this question, the one taking the stand that no increase of tension would take place, the other that the pressure of the steam would add itself directly to the initial tension on the bolts.

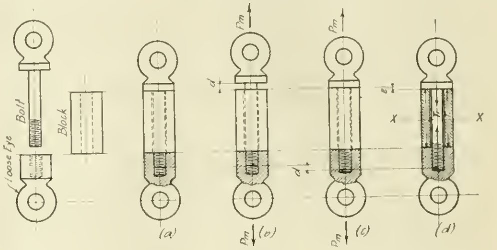


Fig. 1.

Barth solves the problem by establishing the principles involved. His method is as follows:

Let Fig. 1 be a double-eye bolt, one eye solid with its body while the other is screwed on. A sleeve or block, which may be more or less pinched by screwing up the loose eye, is slipped over the body.

As represented in Fig. 1a the loose eye is supposed to be screwed on so as to just draw the arrangement "home," or in other words it is screwed on until the faces of the eye and bolt are tight against the block but not so tight as to stress the pieces. In Fig. 1b the bolt has been stretched an amount d by a pull Pm. In Fig. 1c the bolt while still under the pull Pm is tightened until the faces of the eye and bolt are again brought "home" against the ends of the block. Finally, Fig. 1d represents the conditions with the pull Pm released. Due to this release the bolt has contracted an amount e, and has simultaneously compressed the block the same amount, the result being that the bolt is stretched (d—e) under a certain tension Ti, and as action and reaction on the end surfaces of the block must be equal, the compression in the block must also be Ti. The tension Ti we may treat as an initial tension in the bolt and it is readily determined in terms of Pm as follows: Since the stretch is proportional to the stress:

$$Ti : (d - e) :: Pm : d, \text{ or, } Ti = Pm \frac{d - e}{d}$$

The difference between the tension in the bolt with the load Pm applied, as in Fig. 1c and the initial tension Ti as in Fig. 1d is,

$$Pm - Ti = Pm - Pm \frac{d - e}{d} = Pm \frac{e}{d} \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Let the cross-section of the bolt be represented by A, the cross-section of the block by B, the modulus of elasticity of the bolt by Ea and the modulus of elasticity of the block by Eb, we have

$$\frac{e}{d} = \frac{AEa}{AEa + BEb} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

This may be called "Barth's equation." It is of wide application.

If the block is of the same material as the eye-bolt, Ea equals Eb, and Equation (2) reduces to

$$\frac{e}{d} = \frac{A}{A + B} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

In Fig. 1d let the portion below the axis x — x be considered with a pull Pw on the eye acting downwards. If this pull is less than the load Pm which has been removed it is evident from Equation (1) that Pw — Ti = Pw e/d.

If Pw = Pm, the pull that will just relieve the pressure between the block and the faces of the eye and bolt, there will be no initial tension in the bolt, it being neutralized by Pm. That is, for all cases when Pw is less than Pm the tension in the bolt equals the initial tension plus e/d times the pull.

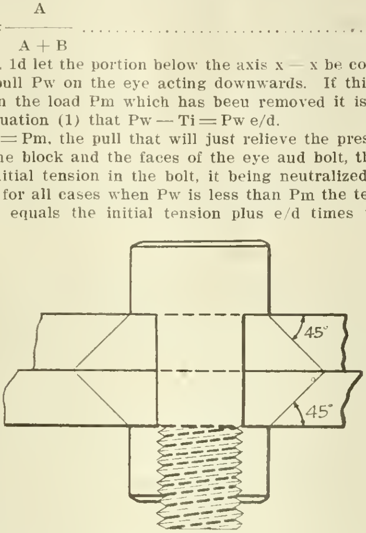


Fig. 2.

For cases when Pw equals or is greater than Pm the tension in the bolt equals the pull.

$$\text{From Equation (1) } Pm = \frac{Ti}{1 - e/d} \quad \ldots\ldots\ldots\ldots\ldots\ldots (4)$$

Let Fig. 2 represent two pieces of ½ in. metal held together with a ¾ in. bolt having a head and nut each 1¼ in. square and tightened until it is under high initial tension. A pull, Pw, is applied to the bolt. The "block" or volume of stressed metal may be considered made of two truncated pyramids each with one base equal to the area under the head or nut and a common base bounded by the intersection of planes making an angle of 45° with the sides of the bases under the head and nut. The area A + B in Equation (3) may be taken as the mean of the two bases or

$$\frac{(1\tfrac{1}{4}\text{ in.} + 1\text{ in.})^2}{2} + (1\tfrac{1}{4})^2 = 3.31$$ and A = 0.44 = area of the bolt cross-section.

$$\text{Then, } \frac{e}{d} = \frac{A}{A + B} = \frac{0.44}{3.31} = 0.13.$$

For all values of pull between Pw = O and Pw = Pm the tension in bolt = Initial tension + 13 per cent of pull. From Equation (4), Pm, the pull that will just release the pressure

$$\text{on the plates} = \frac{Ti}{1 - 0.13} = 1.15\text{ Ti.}$$

For values of Pw equal to or greater than the initial tension + 15 per cent, the tension in the bolt equals the pull.

For example, assume an initial tension of 5000 lb. in a bolt. Then Pm = 5000 × 1.15 = 5750 lb.

If Pw = 1000 lb., tension in bolt = 5130 lb.
If Pw = 5000 lb., tension in bolt = 5650 lb.
If Pw = 5750 lb., tension in bolt = 5750 lb.
If Pw = 6000 lb., tension in bolt = 6000 lb.

An excellent theoretical treatment of rivet stress and initial tension is given by Jacob M. Friedland in an article, "Stresses in Rivets Used in Direct Tension" (Engineering News, Feb 17, 1916, page 308). As outlined in the article, Fig. 3 shows a rivet between whose heads is metal of a thickness 2l. It is assumed that the volume of stressed metal consists of two truncated cones base to base (on the axis) with an angle of 90° at the apex, the rivet hole being deducted from the area, and that within this volume the compressive stresses are uniformly distributed over each horizontal layer, decreasing in intensity as the layer increases. The minimum area, under the rivet head, is equal to that of the under side of the rivet head.

A load p is assumed to act downward on a layer located x inches above the apex of the lower cone. Part of p, say w, will compress the metal x — e below the layer, and reacting against the rivet head, will stretch the rivet shank; while the remainder p — w will stretch the metal h — x above the layer. The elastic deformation is such that the stretch in the rivet plus the compression in the metal below p must equal the stretch in the metal above p. If s is the area of any horizontal layer of metal, dx its thickness, E the coefficient of elasticity of steel, r the cross-section of the upset rivet shank, the above equality is given by the equation.

$$p - w\int_x^h \frac{dx}{Es} = w\int_e^x \frac{dx}{Es} + \frac{wl}{Er}$$

By a complex mathematical process, w/p, the proportion of the load p that tends to increase the initial rivet stress, is found. Applying this formula, Friedland finds the precentage of suspended load that tends to increase the initial stress in the rivet to be from 6.33 per cent for two ⅝-in. angles with 4¾- in. plates between held by a ⅞-in. rivet to 13 per cent for two ⅜-in. angles back to back held by a ⅞-in. rivet. If ¾-in. rivets were used the percentages would be a trifle smaller.

From the formulas of both Barth and Friedland it is seen that a suspended load always adds to the initial stress in a bolt or rivet. In actual practice, as long as the initial stress is not exceeded by the full, the tension in the bolt or rivet will not exceed the initial stress by more than 10 or 12 per cent.

It may be noted here that the amount of initial tension in bolts and rivets is uncertain. A workman with a wrench may put a high initial tension in a bolt or he may leave the nuts so slack that there is none. Some German experiments made a few years ago on ordinary rivets driven with a hydraulic riveter showed tensile stresses of 31,000 lb. per square inch of rivet cross-section. Of course when rivets become loose initial tension disappears.

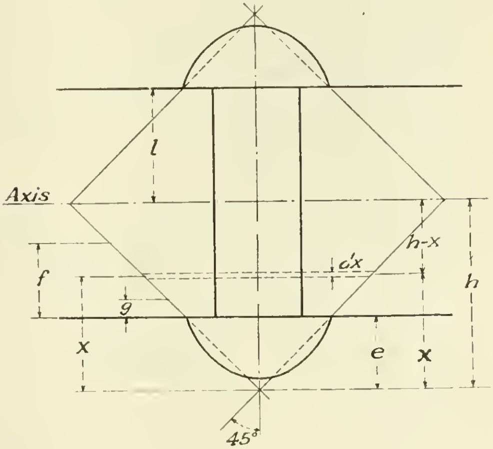


Fig. 3.

Counters.

A counter in a truss is a web diagonal in tension under certain partial loadings. When made adjustable it is often specified that it be given an initial tension. This is done to prevent vibration. In pin-connected bridges initial tension in counters prevents hammering at pin holes due to release and sudden re-application of load. The earlier writers on initial tension treat the subject in an arbitrary but very simple manner. DuBois, as late as the 1902 revision of his "Stresses in Framed Structures and Designing" has the paragraph:

> Initial Tension.—Many of the tension members are made adjustable by means of turn-buckles or sleeve nuts. The screwing

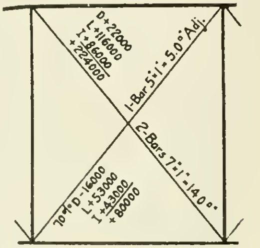
up of these may bring a strain upon the member independently of the strain which comes upon it from the loading. To allow for this we may add 1 ton for a rod 1 in. in diameter and ¼ of a ton for each increase of ⅛ in. in the diameter. That is for round bars.

Initial tension in tons = 2d — 1, where d is the diameter in inches. Flat bars are to have the same allowance as round rods of equal sectional area; or for flat bars:

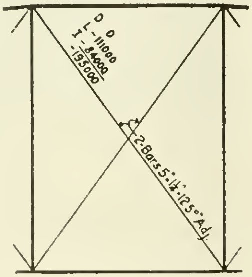
Initial tension in tons = $2.25\sqrt{A} - 1$, where A is the area of cross section in square inches.

More attention has been given of late years to counter ties of bridge trusses with the result that they are not as easily disposed of as in earlier specifications and textbooks. The results obtained from the consideration of initial stress in counters vary, or seem to, according to the textbook followed. For instance, the stresses in a counter with a given initial tension calculated according to the method given in Marburg's "Framed Structures and Girders" will at times differ from those obtained by using the method given in Heller's "Stresses in Structures." In this case the difference is due to the interpretation placed upon the term "initial tension." According to Marburg's method, initial tension is the stress in the counter when only the dead load is acting. According to Heller's method, initial tension is the stress which would remain in the diagonals if all external shear were removed. The writer prefers the method of Marburg because it is more in accordance with actual conditions. Marburg's conclusions are: (1) that moderate initial stresses induced by tightening the counters produce either no effect or only a slight effect on the resultant maximum stresses in the counters and main diagonals; (2) that when the initial stress becomes a factor in the determination of the maximum stress in a member that stress is statically indeterminate: and (3) that excessive initial stress should be avoided.

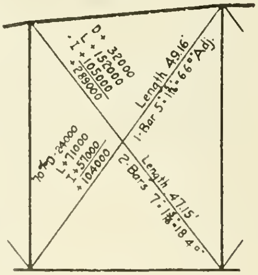
In the best modern bridges the counters are built-up members capable of resisting either tension or compression. For determining stresses a method such as that given by Johnson, Bryan and Turneaure in their "Modern Framed Structures," Part I. "Stresses in Redundant Members" should be followed.



SKETCH I.



SKETCH II.



SKETCH III.

A synopsis of the general subject of initial tension in counters of bridge trusses, handed the writer by a colleague, H. W. Troelsch, is as follows:

1. The initial tensions remaining in the two diagonals of a panel when the external shear is reduced to zero must balance each other, and for rectangular panels will be equal.

2. Any external shear will then be distributed as shown by analysis for indeterminate stresses, assuming the members capable of resisting tension or compression. These stresses should be added algebraically to the initial tension.

3. If the members cannot resist compression, then, as soon as the compression in one of them, found according to "2" exceeds the initial tension, that member ceases to act and the system becomes statically determinate.

4. For rectangular panels with all other members so rigid that their deformations are negligible, the stress in the diagonals from external shear will be proportional to the areas of the members. The shear required to neutralize the initial stress will differ for the two diaognals if their areas differ. If the two members have equal areas, the stresses from external shear will be equal, and the total shear required to neutralize the stress in one member will be that required to produce twice the initial stress in a single diagonal.

It may be noted that all stresses due to initial tension are more or less statically indeterminate. The panels are not hinged at the corners, which adds to the uncertainty of the distribution of stress. An erection foreman was puzzled to know why in screwing up the counters the main ties in an adjoining panel buckled. As the top chord was of large sectional area and continuous over two panels, the reason is easy to see.

More difficult than the theoretical determination of the effects of initial stress is the erection problem of the proper adjustment of the members affected. In simply supported trusses initial stress can occur only in redundant members. The truss is erected with these members slackened, after which they are adjusted, thus bringing on initial stresses. For counters with turn buckles or sleevenuts we are dependent upon the judgment and skill of the erection foreman in tightening the adjustment as he thinks proper, thus bringing in the rods an indeterminate amount of initial tension.

For counters without adjustment the problem is especially difficult. Richard Khuen, Jr., General Manager of Erection, American Bridge Co., has prepared for the use of his department a pamphlet relating to counter bars. By permission of Mr. Khuen this pamphlet is reproduced in the following:

Counter Bars.—The connecting of the two pieces in counters (either by riveted splice plates or turn buckles) in bridges is an important detail in connection with the erection of a span, which should be carefully and accurately done, as the bar is liable to become slack if it is not subjected to sufficient initial stress while the connection is being made.

To determine the amount of initial stress it is assumed that the live load stress (plus impact) for which the main diagonal is designed will be distributed between the main diagonal and the counter in proportion to their areas, as an increase of tension in the former and a decrease of the initial stress in the latter. The initial tension should, therefore, be made equal to the counter's proportion of the maximum live load and impact stresses.

Referring to Sketch I, the initial tension applied to the counter would be 5-19 x 202,000 lb.: or 53,000 lb. = 10,600 lb. per square inch. This would be reduced to zero when the maximum stress was developed in the main diagonal.

In the case of a center panel, illustrated in Sketch II, where both diagonals are counters and of equal areas, the initial stress would be made equal to one-half the maximum stress for which the counters are designed.

If the top chord is inclined, as in Sketch III, the two diagonals have unequal inclinations and lengths, and the initial stress applied to the counter will induce a stress in the main diagonal that is less than that in the counter. These stresses are directly in proportion as the lengths of the two members. The difference in inclinations will also affect the distribution of the live load and impact stresses between the two members. In the case illustrated in Sketch III, the initial tension in the counter should be:

$$\frac{6.6}{25.0} \times \frac{49.16}{47.15} \times 257{,}000 = 70{,}700 \text{ lb. or } 10{,}700 \text{ lb. per square inch.}$$

This will induce in the main diagonal a stress of $\frac{47.15}{49.16} \times 70{,}700$ lb.

67,800 lb.

Now if the live load comes on from the left so as to produce maximum stress in the counter (128,000 lb.) the live load and impact stress in the main diagonal will be:

$$\frac{18.1}{25.0} \times \frac{47.15}{49.16} \times 128{,}000 \text{ lb.} = 90{,}400 \text{ lb.}$$

compression, which will be offset by the dead load and initial tension amounting to 99,800 lb., leaving a residue of tension of 9,400 lb. The live load and impact stress in the counter will be:

$$\frac{6.6}{25.0} \times 128{,}000 \text{ lb.} = 33{,}800 \text{ lb.}$$

tension, which added to the initial tension of 70,700 lb. makes a total of 104,500 lb. This is 500 lb. more than the maximum counter stress given on the stress sheet. Since a combination of conditions might exist under which the above method of determining the amount of initial stress would develop a possibility of excessive stresses in the counter or diagonal, every case should be investigated to determine whether any modification is necessary.

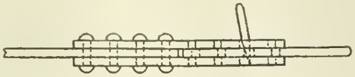
The initial stress should always be applied after the bridge is swung and carrying a full dead load.

Locomotives, cranes and derrick cars are usually employed for putting the load in the main diagonal when a counter is being connected, and should be run out on the structure to produce maximum stress in main diagonal.

On heavy bridge work where the counter bars are spliced in the field, the initial stress can be put into them as follows:

(a) Shop rivet the splice plates to the lower piece of the counter bar.

(b) Sub-drill the holes in the upper part of the splice plates and the lower part of the top piece of the counter bar, as shown in sketch.



(c) The initial stress may be applied:
- 1st By driving drift pins to stretch the bar, as shown, until the holes match.
- 2nd. With turnbuckles and rods attached to lugs riveted on each side of the two pieces of counter, etc.

The relation of the sub-drilled holes in the lower end of the upper piece of bar to the sub-drilled holes in the upper end of the plates will depend upon the amount the whole bar should be elongated under the required initial stress, which will be determined by the drawing room and recorded on the drawings. The drawing room should use length of counter with bridge under dead load minus play in pin holes as original length from which to deduct elongation for initial tension.

The drift pins should be of a gradual taper to a point of about 1/8 in. in diameter and when the holes are matched they can be drilled full size and filled with long barrel drift pins and bolts preparatory to riveting.

Mr. Khuen advises the writer that for years he has been wrestling with the practical side of erecting non-adjustable counter members. Often after counters had been riveted and put in place rivets would become lose and had to be replaced, usually at considerable expense. The scheme proposed in the pamphlet has not yet been fully tested but gives something definite from which to work. Modifications can be made as further experience shows them to be necessary.

Lateral Systems.

In the earlier iron bridges the diagonal members of the top and bottom lateral systems were made of rods with turnbuckle adjustment. In order to avoid excessive vibration it was usually specified that an initial tension should be given to these rods. The "Specifications for Iron Bridges," 1887, of the Atchison, Topeka and Santa Fe Railroad were typical of many:

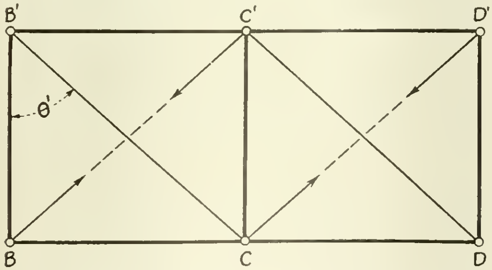


Fig. 4.

> In proportioning the lateral members it shall be assumed that each lateral tension member will be given an initial tension strain of 10,000 lb. in the adjustment of the bridge. Laterals in compression shall be proportioned to resist the resultant of these strains.

A similar clause is occasionally found in bridge specifications today.

In contrast to the foregoing, Waddell in his "Bridge Engineering"—"Laterals and Sway Bracing"—bluntly writes:

> Furthermore, it is specified that, for important highway bridges and all railway bridges, the members of the lateral systems must be capable of resisting compression as well as tension, and this requirement will bar out adjustable rods and light, flimsy angle members.

The American Railway Engineering Association in its specifications for steel railway bridges calls for bracing in all structures to be composed of rigid members and the minimum sized angles used in lateral bracing to be 3½ x 3 x ⅜ in.

To guard against slackness in angle diagonals the engineering department of some railways and fabricating companies observe the following rule:

> For diagonal bracing of one or two angles the following draw should be allowed:

For lengths up to 10 ft......	No allowance.
From 10 to 21 ft...........	Allow 1/16 in.
From 21 to 35 ft...........	Allow 1/8 in.
Over 35 ft.................	Allow 3/16 in.

Scores of light highway bridges are built every year in which the diagonals of the lateral systems are adjustable rods. Initial stress is treated in Merriman and Jacoby's "Roofs and Bridges," Part I, Sixth Edition, as follows:

> In Fig. 4 are shown two panels of a lateral system and two arrows are inserted in each panel to represent equivalent external forces acting upon the panel when one of the adjustable diagonals is drawn up by means of its turnbuckle or sleeve nut. If these forces in the first panel be designated by P, the stress in the chords BC and B'C' are each — P sin θ', those in the struts B'B and C'C are — P cos θ', and that in the tie B'C is + P. Only the members connected with any panel are affected by initial tension in its diagonals. Similarly, if P' be the initial tension in the second panel, the stresses in its chords are — P' sin θ', in the struts — P' cos θ', and in the diagonal + P'. As C'C belongs to both panels, its total initial stress is — (P + P') cos θ'.
>
> The stresses in the diagonals due to the initial tension are not to be added to those due to wind in order to obtain their maximum stresses, because the shear in any panel caused by the external wind loads replaces a part of the initial tension in one diagonal, while it releases the same part of the initial tension in the other. The value of the tension so replaced in one and released in the other diagonal is ½ V sec. θ'. The corresponding release for the chords is ½ V tan. θ', and for the struts ½ V, in which V represents the shear in the panel due to wind. In case the greatest wind stress in either diagonal be equal to twice the initial tension, the effect of the latter entirely disappears in every member of the panel. Therefore, if the wind stress be less than this amount, the maximum stress equals the initial tension, and if the wind stress be greater, its value will be the maximum stress (Merriman and Jacoby use — to denote compression and + to denote tension.)

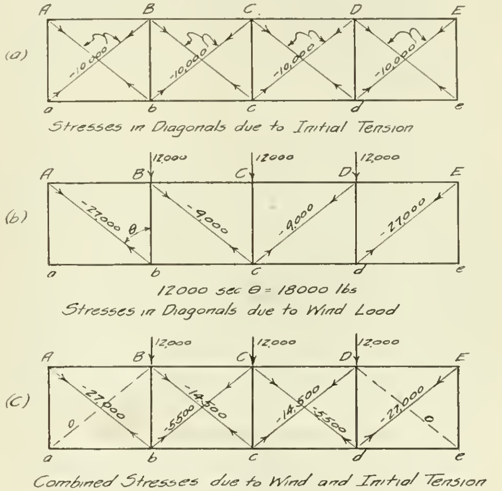


Fig. 5.

The foregoing in the use of the word "replaces" and in the first part of the last sentence is incorrect. For a wind stress less than twice the initial tension, the maximum stress is not the initial tension but is the initial tension plus one-half the wind stress. This is correctly shown in Fig. 5 (taken from Ketchum's "Design of Highway Bridges"). Ketchum uses + to denote compression and — to denote tension.

Ketchum's "General Specifications for Steel Frame Buildings" calls for an initial stress of 5,000 lb. in each member of lateral bracing and adds, "provision must be made for putting this initial stress into the members in erecting." The present writer recommends that for calculations, both high way bridges and buildings, an initial stress of 5,000 lb. be assumed for each lateral rod. However, the amount of initial stress actually in the structure after the erection foreman has adjusted the rods is indeterminate.

Wages in Building Trades in Western Cities

The accompanying table has been compiled from replies to a questionnaire sent out by the Chicago Daily News. Since its preparation the Chicago Masons and Builders Association has granted an increase of 25 ct. per hour to bricklayers, with double pay for overtime. It is understood that a similar increase will be given carpenters and other craftsmen in the Chicago building trade.

The following comments on the situation in the building trades in the cities included in the table are also taken from the Daily News of March 12:

Detroit—"No special scarcity of labor, but one is expected when building opens up in next few weeks. Most building trades organized work eight hours. Few not organized work nine and ten hours."

Peoria—"Moderate labor shortage. Iron workers have 85 ct. scale, but are receiving $1. Other labor getting little bonus."

Indianapolis—"Under contracts expiring April 1 carpenters are getting 75 ct., bricklayers $1, plasterers 87½ ct. Eight-hour day. No shortage of labor. Carpenters are asking $1 and bricklayers are asking $1.25 for new contracts."

Gary—"Building trades in chaotic state awaiting Chicago settlement, as Chicago scale has always governed here and will continue to do so, both builders and craftsmen declare. Unions demanding 15 to 25 per cent increase. effective April 1. No adherence to scale for some time; while scale for carpenters has been $1, most of them are getting $1.25 to $1.50 an hour. Similar conditions exist in other lines of building trade. No scarcity of labor now, but labor famine is predicted with big building boom coming."

Denver—"Business agents report work fair to good, with little work for outsiders. There is no scarcity. Eight hours is the basic day. Many plumbers and steam fitters idle. Carpenters, $1; bricklayers, $1.25; steamfitters and plumbers, $1, leading scales."

Pittsburgh—"Bricklayers, $1.12½; carpenters, 90 ct.; common labor, 50 to 60 ct., paid for 8-hour day basis here. There is a scarcity of hodcarriers and common labor. Negotiations for increased scales to begin April 1."

Milwaukee—"Carpenters, 70 to 90 ct.; masons, $1.25; plasterers, $1.12½; lathers, $1; common labor and hodcarriers, 75 to 80 ct.; bricklayers, $1.25, are wages paid in building trades here."

Kansas City, Mo. "Eight-hour day prevails. Effective May 1 bricklayers will get $9 a day, masons $8, carpenters $6.80. Plenty of workers in building trades. Carpenters will ask $1 an hour, effective May 1."

Grand Rapids—"Carpenters, 90 ct., 9-hour day; bricklayers and masons, $1.10 an hour, 8-hour day; steamfitters and plumbers, $1; laborers from 50 to 60 ct. There is a scarcity in all trades and it is difficult to employ men."

St. Paul—"Carpenters get 75 ct., bricklayers $1, painters 75 ct., plumbers 87½ ct., 8-hour day. No great shortage."

Minneapolis—"Minneapolis building trades working under last year's agreement, but are demanding increases. Carpenters getting 75 ct., asking $1; bricklayers, $1, asking $1.25, etc. Common labor, 50 ct. an hour; 8-hour day prevails. Builders say there is no shortage."

Omaha—"Carpenters get $1.12½ an hour for one year after March 13; bricklayers get same and after June 1, $1.25; plumbers get $1.12½ to April 1, thereafter $1.25. Common labor gets 50 to 87 ct. and asks 75 ct., 87 ct. and $1 an hour, according to class; 44-hour week. No scarcity in any class."

Cleveland—"Bricklayers, electricians, plumbers, etc., $1 present scale; carpenters, 90 ct.; painters, 80 ct.; labor, 57½ ct. Because of competition this scale is generally materially increased. Scarcity exists. Some 10,000 building trades men here. Building slowing down because of labor and material cost. New scale demanded for April 1, $1.25 to $1.35 for most classes."

Cincinnati—"Carpenters get 90 ct. an hour and are striking for $1 now and $1.25 effective May 1. Plumbers get 80 ct. now, 85 ct. May 1. Plasterers, $1; bricklayers, $1; new scale May 1 gives them $1.25. All work 8-hour day."

Columbus, O.—"Eight-hour day for building trades here; labor generally scarce except carpenters. Bricklayer shortage acute. Bricklayer scale, 87½ ct., $1 being paid; carpenters, 85 ct.; masons, 90 ct.; hodcarriers and labor, 65 ct."

Toledo—"Wages in building trades here are high and unusual scarcity prevails. Carpenters, plasterers, painters and plumbers each get $1 an hour for eight hours. Bricklayers and house electricians receive $1.25. New scale effective April 1 calls for 25 per cent increase."

St. Louis—"Eight-hour day prevails, 44-hour week. There is no scarcity, every job is manned to the full capacity. Principal lines receive $1 or more per hour by agreement effective March 1."

New Committee on Standard Specifications for Concrete and Reinforced Concrete.—The Joint Committee on Standard Specifications for Concrete and Reinforced Concrete, consisting of 5 representatives from each of the following organizations, American Society of Civil Engineers, American Society for Testing Materials, American Railway Engineering Association, Portland Cement Association, American Concrete Institute, was organized Feb. 11, at which time the following officers were elected: R. L. Humphrey, chairman; J. J. Yates, vice chairman, and D. A. Abrams, Chicago, secretary-treasurer. The purpose of the committee is to make a thorough study of all available data on the subject of concrete, concrete materials and reinforced concrete and to incorporate the most modern information and experience into a general specification which may serve as a pattern for detailed specifications covering specific types of concrete construction. The new committee may be considered as the successor of the "Joint Committee on Concrete and Reinforced Concrete" which was organized in 1904, through the cooperation of the same engineering and technical societies. The original joint committee presented its final report to the parent organizations in 1916. A number of the committees have organized and are actively engaged in the preparation of their preliminary reports. The next meeting of the committee will probably be held at Asbury Park, N. J., about June 22, during the annual convention of the American Society for Testing Materials.

WAGES PER 8-HOUR DAY IN BUILDING TRADES IN MIDDLE WESTERN CITIES ON MARCH 1.

	Common labor.	Bricklayers.	Carpenters.	Masons.	Plasterers.	Structural steel workers.	Plumbers.	Gas and steam-fitters.	Roofers.	Painters.
Chicago	$0.75	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00	$1.00
Detroit	.65-.90	1-1.25	.75-.90	1-1.25	1-1.25	1.00	1.25	1.25	.80-1.00	.80-.90
Peoria	....	1.00	.87½	....	....	.85-$1	....	....	....	..
Indianapolis	....	1.00	.75	....	.87½	....	....	....	....	....
St. Louis	.60-.70	1.12½	1.00	1.12½	1.12½	1.00	1.12½	1.12½	.85	.75
Gary	.75	1.00	1.25-.50	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Denver	....	1.25	1.00	....	....	....	1.00	1.00	....	....
Pittsburgh	.50-.60	1.12½	.90	1.00	1.00	1.00	1.00	1.00	1.00	....
Milwaukee	.75-.80	1.25	.70-.90	1.25	1.12½	....	....	....	....	....
Kansas City, Mo.	....	1.12½	.85	1.00	....	....	....	....	....	....
Grand Rapids	.50-.60	1.10	.90	1.10	.75-.85	....	1.00	1.00	....	.75
St. Paul	.50	1.00	.75	....	.90	.87½	.87½	.87½	....	.75
Minneapolis	.50	1.00	.75	....	.90	.87½	.87½	.87½	....	.75
Omaha	.50-.87	1.12½	1.12½	....	....	....	1.12½	....	....	....
Cleveland	.57½	1.00	.90	....	.90	....	1.00	....	1.00	.80
Cincinnati	....	1.00	.90	....	1.00	.84	.80	.81¼	....	.75
Columbus	....	.87½	.85	.90	.87½	....	....	....	.65	....
Toledo	....	....	....	....	....	....	1.00	....	....	1.00

Plastered or Concrete Gun Types of Concrete Houses*

The plastered or gunite concrete house is one having a reinforced concrete structural framework, either cast in place or shot with a cement gun and having comparatively thin exterior double walls of concrete formed by plastering or shooting concrete on expanded metal, or mesh reinforcement. This type may or may not have concrete floors and roof. If not of concrete, metal lumber makes the best substitute. Wood floor joists and wood stud partitions can be used when economy in first cost is demanded.

One of the greatest, if indeed not the greatest, objection to monolithic concrete construction is the bother and expense of forms. This is particularly true of dwelling house construction because of its endless variety, with complications of openings, angles, etc. There can be no question but that the ultimate to be desired in concrete house construction is a design in which every piece that is erected remains put and forms a permanent, integral, necessary part of the structure.

The first fundamental idea of this group of designs is the matter of insulation against heat conduction.

Insulation is a matter which vitally affects the comfort of a house, as well as the cost of heating it. Control of heat loss and ventilation is fundamental to success in the design of a heating plant, and such control cannot be obtained with exterior walls having poor insulating qualities. Insulation of exterior walls of houses is also required to prevent condensation of moisture on the interior surface of these walls, regardless of the type of construction. Masonry walled houses are always furred, lathed and plastered on the inside, thus producing an air space between the masonry wall and the interior of the house, which furnishes the required insulation to prevent a sufficient difference in temperature being established between the wall surface and the air within the house to cause condensation. Concrete houses, of whatever type, are no exception to this requirement for insulation, and the designers of this group make it possible to supply the requirements of insulation by including a dead air space in the wall proper. The plastered and gunite types have a concrete exterior wall about 2 in. thick, separate from the interior finish by a dead air space.

Any air space in a wall to be effective must be "dead," that is, have no connection with the outside of the building, and should be limited to such width and arrangement as to prevent convectional currents of air being set up within the dead air space itself. The outside wall of the plastered or gunite house is usually only from 1½ to 2 in. thick, but this wall is reinforced in all directions by expanded metal or mesh reinforcement which is completely imbedded in the wall. The wall is moreover supported on all four sides by the reinforced concrete framework so that it is required to act merely as a "curtain" wall. Good workmanship will insure a very dense wall 1½ or 2 in. thick which is not only impervious to moisture under the most severe weather conditions, but also prevents any appreciable transfer of air between the dead air space and the exterior. While the wall itself possesses some insulating value, it is to be remembered that the entrapped air within the dead air space is depended on for insulation.

If a very high degree of insulation is desired, this type of construction allows the use of various insulating mediums, such as heavy waterproof building paper, corkboard, linofelt, Cabot's quilt, insulite or flax-linum, etc., which can be applied in sheets directly to the inside surface of the outside wall.

The second fundamental requirement is fully met by this method of construction but an examination of building codes in various cities reveals the fact that the requirements of the construction of ordinary dwelling houses are based on familiar practice in the construction of masonry walls comprised of small units set in mortar, or on frame construction. The plastered or gunite type of house, as above defined, may truly be said to be a new type of construction to most building commissioners and inspectors. It is not to be expected, therefore, that present building codes provide directly for the use of such construction. However, this type does fulfill the fundamental requirements of strength and fire-resistive qualities. The structural framework is of reinforced concrete cast in place or shot into place with a cement gun. The sizes and reinforcing of the various structural parts are easily varied to meet all specified load conditions and are matters of simple engineering design. The exterior walls are, of course, thin as compared with those specified for ordinary masonry bearing walls, but it should be borne in mind that this is an entirely different type of construction. The exterior walls of the plastered or gunite type of house have a reinforced concrete frame which in conjunction with the reinforced thin slabs make strong and rigid bearing walls and have the elements of strength of the well known reinforced concrete floor. Lack of familiarity is, therefore, the only excuse for hesitation in allowing this type of dwelling house to be constructed within the fire limits of cities or in any other localities.

The results of such tests as are available on the fire-resistive ability of a concrete wall 2 in. thick, reinforced with mesh or expanded metal, indicate its ability to withstand the 2-hour fire test without serious injury. It will be recalled that the usual building code requirement for the thickness of concrete covering over reinforcing for flat surfaces, such as in floors, is from ¾ in. to 1½ in., with an average of about 1 in. This indicates at once that the exterior reinforced concrete wall, 2 in. thick, practically fulfills the usual building code requirements for fireproofing even the large fireproof buildings.

For usual dwelling houses there is not sufficient combustible material to produce a fire of sufficient intensity and duration to affect in any serious way the reinforced concrete framework of this type of building. A favorable insurance rate is, therefore, justified for this type of construction.

Another point that occurs to your committee in examining this group of designs is the fact that there has been introduced here an entirely new element of safety, elsewhere non-existent.

It will be noted that in these designs there is a form of wall construction consisting of relatively thin walls with relatively a very high degree of steel reinforcement, all thoroughly knit together into a strong unit. The effect is the same as that of wire glass. It may be cracked and broken, but it will not go to pieces. Not only should it be in a high degree cyclone and earthquake-proof, but it should be like wire glass, flame resisting.

The conclusions which your committee reaches after examining the designs available in this group are as follows:

1. All structural requirements are fully met in the plastered or gunite type of house herein defined.

2. The framework and walls of this type are of fireproof material and are sufficient to withstand without serious injury any conceivable dwelling house fire.

3. It follows from conclusions (1) and (2) that building codes should allow this type of construction within the fire limit of cities, and that insurance rates should credit in full this type as fireproof construction in all portions where concrete is used.

4. The insulating qualities of the double wall produced by this type (or method) is sufficient to prevent condensation of moisture on the interior of experior walls and insulating mediums can easily be applied to obtain any desired degree of insulation.

5. Concrete floors produce a thoroughly fireproof and sanitary structure. Concrete floors should preferably have embedded nailing strips or be covered with a layer of nail-coat to which a wood floor may be nailed or be covered by rugs, carpets, or special, easily removed floor coverings.

6. The use of plastered or gunite concrete houses lend themselves to flexibility of design so that the architect is not hampered by any predetermined unit in working out the design of his building. Furthermore, he can have different texture finishes for the exterior walls and trim the building with wood porches, cornices and the like as is customary in the standard wood frame covered with stucco, while at the same time securing the fireproof qualities in the exterior of the wall construction with a minimum expenditure of material, which is about one-third of what a monolithic 7 in. wall would be, thus conserving materials and operating to keep the cost of construction at a point that more houses can be built for a given amount of money than would be the case where heavy masonry walls are used.

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*From a committee report presented at the National Conference on Concrete House Construction, held Feb. 17, 18 and 19, at Chicago.

SCIENCE OF MANAGEMENT

Application in Civil Engineering and Construction Fields

The term Science of Management was coined by the editor of Engineering and Contracting and first used in "Cost Analysis Engineering" (1908) and explained more fully in "Cost Keeping and Management Engineering" (1909). The last named book, which contains ten laws of management and many subsidiary principles, was the first book on the science of management. In the columns of this journal many additional laws, principles and detail methods of management have been published. This section, which appears weekly, may be regarded as a serial sequel to the two books above named.

Woolworth's Successor and His Success

Engineering and commercial economics differ in detail only, and the student of either may profitably take many a page out of the book of the other. It is therefore with real pleasure that we abstract for the benefit of our readers an article from a recent issue of The American Magazine in which Mr. B. C. Forbes presents some of the personal characteristics, scientific and business methods which have lead to the success of Mr. Hubert T. Parson in handling the largest retail business in the world—that of the 5 and 10-cent stores of the F. W. Woolworth Co.

It would be interesting to know how many engineers have had their curiosity aroused by this institution.

Personally, as we have passed or patronized one of these stores, we have found a sort of mystery in the success which is understood to have attended them. How could a business of such a character have made the fortune attributed to this one? "Volume of business," say you? Yes, volume of business is an obvious element, and we are ready to admit that it may exceed anything of which we have dreamed; but "volume of business" cannot tell the whole story, and we remember the tale of the Hebrew merchant who, after selling for 2 years at "less than cost," was asked how he escaped failure, and replied, "Ah, but think of the volume of the business." Mr. Forbes, in his article, tells something of the volume of the Woolworth business, but he also explains some of the principles and methods which, combined with that volume, have produced an economic achievement.

First, let us take a glance at a few statistics of the business for the year 1918:

Number of stores	1,060
(At least one in every U. S. town of 8,000 or more population, and numerous others abroad.)	
Number of patrons	1,000,000,000
Number of sales	2,000,900,000
Profits	$7,000,000
Pounds of candy sold	30,000,000
Pairs of hosiery sold	50,000,000
Sheets of music sold	20,000,000
Nursing bottles sold	1,714,000
Cakes of soap sold	15,000,000

Of more interest to engineers is the personality of the man who was the unanimous choice of Mr. Woolworth and the board of directors as the active head of the business.

Minute Knowledge and Trained Memory as Leading Factors in Attaining Success.—If you have felt that a general knowledge of your profession was sufficient; and that so long as plenty of good books were at hand there was no need of taxing your memory, read the following:

"I asked a high-up Woolworth executive to define in a sentence or two Mr. Parson's most conspicuous qualifications and characteristics. He reflected for a little and then replied:

"'Parson knows more about the five and ten cent business than any other man living. He is probably without a peer as an organizer. He is a master of system. He has devised systems of book-keeping and record-keeping that enable him to see at a glance what every store in every locality is doing. His forms and schedules show him where there are undue leakages or waste or losses or poor management. He has an uncanny memory; he carries in his mind a complete picture of what is going on every day in our thousand stores, and can quote almost any figure or fact pertaining to the business without consulting the records.

"'Yet, combined with this mastery of detail, he has as much foresight as Mr. Woolworth had. It was his amazing grasp of detail, his wonderful memory, and his rare foresight that led Mr. Woolworth to make him his right-hand man as vice president and general manager. He is now one of the administrators of the Woolworth estate.

"'No man in the organization works harder than Parson. Mr. Woolworth used to say that in the early days of the business Parson worked so late that on his way home he met himself coming back to work in the morning. Also, and perhaps most important of all, Parson has in an extraordinary degree what, for want of a better term, we call judgment—a combination of common sense, vision and insight born of his enthusiastic devotion to the business, his mature experience.'

"Then he added, 'The only thing I might say by way of criticism is that he has been too busy attending to business to learn how to be a good mixer. He's not strong on superficial personality. But he can deliver the goods every time.'"

Small Unit Profits—Large Totals.—The average purchase in a Woolworth store is 13 cts., and the profit upon it is ½ ct. or 4 per cent. An attempt to check this from the other figures given indicates a small discrepancy, but whether the profit be 4 per cent or 3 per cent is not of primary concern to us, for the total profit runs into many millions. Quoting further from Mr. Forbes' article:

Delegation of Duties.—"Mr. Woolworth once told me that the turning-point in his career did not come until he learned, at the expense of a breakdown that almost cost him his life, that there were things other people could do as well as he could himself. He added:

"'I then learned to entrust duties to other people. So long as I was obsessed with the idea that I must attend personally to everything, large-scale success was impossible. A man must select able lieutenants or associates and give them power and responsibility. . . . .'

"It was he, more than any other individual, who taught Woolworth that there were many duties which could be delegated to assistants. It was Parson who plodded and planned to give correct, businesslike form to Woolworth's ambitious dreams. It was Parson's installation of systematic compiling of records, of cost-analyses, of uniform merchandising forms—it was his wizardlike ability to develop order and organization that prevented his chief from having another breakdown, and freed him to go into the field and expand with unprecedented rapidity. How invaluable Parson became in upbuilding Woolworth's may be gathered from this reply Woolworth once gave me when I asked him for some figures:

"'Ask Parson. He knows more than I do. He knows everything about the business.'

"He knows everything about the business. In that one short sentence does there not lie the explanation of Parson's phenomenal rise?

"Parson, please understand, was not pitchforked into high place. He had to earn each step."

Scientific Operation and Management.—"'For example, every location for a store is chosen, not by hit or miss, but on scientific principles. We never make a move on impulse, on mere theory, on guesswork. We not only look before we leap, but we take detailed measurements of the ground where we are going to land. Success cannot be attained by working in the dark; you must all the time know why you should or should not do a thing, and what the results are likely to be.

"'There are two parts to every business: dealing with the public and dealing with your own organization, your own employes. The public wants the greatest possible value for its money; this applies to rich and poor alike, we have found by experience. In dealing with employes, we have found that by far the best plan is to give every individual in the organization, wherever it can be done, a share of the profits they themselves help to make.

" 'There are practically in our whole force, from store manager up, only myself and three vice presidents who draw a salary. Every store manager is dependent upon the profits his store makes; every district manager's income is regulated by what his district makes; and those of us who are executives at headquarters get a share of the general results for the year. This means that every responsible employe, particularly every manager of a store, feels that he is a direct partner, and that the greater the profits the larger the income received.

" 'You cannot run any large enterprise successfully without loyalty and enthusiasm through all ranks. The way to secure this loyalty and enthusiasm is to pay for it. Every man has a chance to develop initiative, and if he makes good he gets a large share of the profit. In a sense each one is in business for himself as a local merchant, part of his local community. He employs his own help, orders such goods as he thinks best and in any quantity he desires. We virtually set him up in business; furnish him a store, stock it with goods, and teach him how to get the best results in store management. The rest is up to him. Of course if he doesn't succeed, we have to put another man in his place. We never go outside the organization for a man to fill any position above a clerk, and all the important men have understudies training to fill their positions at any moment.'

" 'You emphasize foresight. Can you give me a concrete illustration?' I asked.

" 'Yes. As soon as it was announced that the United States Steel Corporation was to build a large plant at Gary, Indiana, we obtained a copy of the plans, studied out which would be the best location, and before fifty houses had been built a Woolworth store was ready to handle the business which we knew would come.

" 'How do we not only look before we leap, but take detailed measurements of where we are to land? Well, for one thing we are constantly compiling what is virtually a census of the United States. We not only procure promptly every helpful report compiled by the Census Bureau at Washington, and by all state census bureaus, but the head of the eleven districts into which we have divided the country keeps the closest possible tab on the trend of population, and reports to us the places that are growing and those that are declining. We shun dead or decaying towns. We open on an average at least one store every week. Very often our decision to open a new store is based upon the statistical information supplied by our own district men, or by our own buyers or traveling superintendents, or others of our 40 men on the road; but not infrequently we receive tips from manufacturers or buyers with whom we do business, from real estate men, or even from outsiders who write to us. Then we watch all newspapers for clues. Every suggestion, no matter what its source, receives careful consideration.

" 'Once we have made up our minds that a certain place looks like a good prospect, we send one of our corps of experts to examine the situation. He finds out everything possible about the general position and prosperity of the town, and if he is satisfied that a store is likely to succeed he proceeds to determine the ideal location. Having ascertained the best and busiest shopping center, he next investigates available space. The next, and very important, step is to take a complete count of the number of people who pass different possible sites each hour of each day. We always go with the business tide; we never attempt to buck it.

" 'It would often be fatal even to open on the left side of a street if the right side is the popular one—and it is curious how many streets there are which are prosperous on one side and not on the other. We found, I recall, when we investigated Brooklyn, that Fulton Street was the choice location, provided we could get space on the east side. Rather than venture to start on the west side, we waited our chance to obtain a building on the best side.

" 'Once a man earns our confidence we give him practically free rein. Mr. Woolworth had very emphatic ideas on this subject, which he once expressed thus: "When you put a man in charge of a branch of your business, leave him alone unless he asks for help. If your judgment was good in putting him there he will not ruin you, and he ought to be trusted. If your judgment is not good, you have no right to be in business."

Service and Progress.—" 'I asked him to tell in some detail just why Woolworth's could sell for 10 ct. many articles which cost a quarter, or even more, elsewhere. This struck a responsive chord, for Mr. Parson feels that there is something more to the Woolworth business than mere money-making, that it has been a godsend to millions of families, that it has saved incalculable amounts for American homes, that it has in many cases improved, not to say revolutionized, manufacturing processes by introducing large-scale, economical production, and that during the war its uncompromising stand against the raising of prices has done not a little to keep down the cost of living for the rank and file of the people.

" 'There are 32 buyers, each of whom handles only one line as, glassware, candy, dry goods, etc.

" 'These men are not simply buyers in the sense that the public thinks of a buyer. They are often creators of merchandise. They sense a demand for an article, or they take an existing article costing twenty or thirty or even fifty cents, study out how it can be produced most economically, take it to an alert manufacturer, go over the whole problem in detail with him, and experiment until the cost has been reduced to a point permitting of its sale at ten cents, or five cents, as the case may be. By turning a whole factory on to one article and keeping it going at full tilt all the year round, wonderful economies can be effected by manufacturers. We do no manufacturing ourselves. It is one of our fixed rules to stick to selling goods.

" 'One of our buyers thought it would be possible to sell for ten cents a genuine gold-filled ring which was catching on at fifty cents. The manufacturer laughed at the feasibility of the idea, and explained that he was already selling enormous quantities of them, 450 dozen in the previous year. The next year he made 720,000 rings, all for us, which we sold at a profit, and which netted him far more than he had previously received.

" 'The war naturally shut off our supplies of many goods, as we normally bought about an eighth of our merchandise from Europe. We wanted to get domestic supplies of a ten-cent iron toy previously obtained in Germany. An American manufacturer took up the problem in earnest, but finally declared that, no matter how large the order, he could not get production down to a feasible point. Our buyer went over his calculations with painstaking care and could find no chance for reducing anything until he reached the charge for painting. The manufacturer assured him his figure represented bed rock. Our buyer went into the factory, saw that rows of girls were painting toys with brushes, and grasped the solution in a flash. "Leave off this little stripe and this little yellow stripe and simply dip the toys in vats," he instructed. We got the toy and the manufacturer got his profit.

" 'Elimination of waste and conservation of by-products are far more important items in the aggregate than you would suppose. Waste material, such as paper and excelsior, is put through a baling press and brings us in more than one hundred thousand dollars a year. All our boxes, barrels, pails, and every sort of container, instead of being torn open in the usual way, are opened with the greatest care, so as not to spoil them for re-use. They are all sold to second-hand dealers and bring us in enough to pay dividends on two or three millions of capital.

Exceptionally Good Business.—" 'We have a system of paying for what we buy which is a real factor in lowering our purchase prices. We pay our bills at least once every week, and, no matter where a manufacturer is located, we send out his check so that it will reach him on Friday, so that he can have the money for his pay roll on Saturday. To many small manufacturers this is a very great convenience, since it means that, as he gets some credit when buying his materials, we practically finance him.

" 'We always pay cash, and as cash discounts average two per cent the sum thus saved on, say, our current year's purchases of approximately $100,000,000, foots up to about $2,000,000. Our prompt-payment rule influences many manufacturers to do business with us, and this, combined with the magnitude of the orders we give, enables us to secure extra favorable price quotations.

" 'The losses of the department stores through bad debts run into millions. We have no bad debts, since we sell only for cash. Bookkeeping incidental to charge accounts is a heavy expense item in department stores. We have no such cost. Delivery costs are terrific in the case of all large stores —simply terrific. We are subject to no such drain. The ordinary department store turns over its capital once or twice a year. We turn over our stock about seven times a year.

"'Yes, this displaying of so many small articles on counters where thousands of people pass, often in crowds, entails a certain amount of loss through pilfering. We figure upon a loss, from all causes, including breakages and thefts, of five per cent from the time goods reach a store until their sale. Our scientific system of keeping records enables us to see exactly where losses rise above normal. We can tell which counter is having a bad record and, of course, we set about locating and removing the cause.'

Woolworth, Man of Courtesy and Goodwill.—"'We attach great importance to courtesy. Mr. Woolworth not only long ago adopted the now popular injunction, "The customer is always right," but he had a habit of every now and again sending a telegram to every store to some such effect as this:

> Good morning! Did you say good morning to each customer this morning?
>
> FRANK W. WOOLWORTH.

Any lack of politeness is fatal to the prosperity of a store.'

Woolworth's Broadmindedness.—"'One of his greatest satisfactions in life was that he had been instrumental in enabling hundreds of his associates to amass fortunes. The more money any of his men made, the happier he was—and of course the better it was for the company, since all commissions earned represented just so much profits for the company. He used to be fond of remarking that some men had one partner and some a few, but that he had more than a thousand. He believed that the best way to build up any business was to give the men in it a chance to earn big money by sharing the profits they directly helped to earn.

"'Another of our principles is to have at least one, and, wherever possible, two understudies for every position in the organization. No matter who becomes sick or dies or goes off on a vacation or a trip, somebody is ready to fill the place efficiently.

"'Organize, systematize, deputize, and economize, has been our guiding maxim. Mr. Woolworth tried always to look and plan five or ten years ahead, and his ambition was to establish a store in every civilized town in the world. Now that the war is over, instead of opening one new store every week, we will be in a position to branch out more rapidly, and although Mr. Woolworth's goal seems a high and distant one, we mean to press courageously toward it.'"

Dangers of Salamanders in Heating Winter Concrete Work.—Whenever reinforced concrete building work is done in the winter seasons, some artificial means of heating the structure must generally be installed. Salamanders are usually used for this purpose. In a weekly news letter of the National Safety Council, Mr. E. W. Bush points out that it is desirable that the salamanders be connected by piping to the outer air, or a chimney, as the burning fuel is a great consumer of oxygen, and workmen who perhaps are tending these fires during the night-time are quite apt to lie down to sleep beside the salamanders, and all the elements are present for a fatality. Reports were recently received of five or six men being knocked out on one job during the first night or two that the salamanders were in use. In another instance, a plasterer who was working on a scaffold near a salamander was overcome by the foul air, pitched forward, and sustained a very serious head injury as the result of his fall.

Standard Size for Common Brick.—The Common Brick Manufacturers' Association of America, at its annual convention last month at Columbus, O., adopted 2¼ x 3¾ x 8 in. as the standard size for brick. This size is also the standard of the A. S. T. M., the American Face Brick Association and The National Brick Manufacturers' Association.

Fabricating Shop Contracts in February.—The records of the Bridge Builders & Structural Society as collected by its secretary, show that during the month of February, 1920, 95 per cent of the entire capacity of the bridge and structural shops of the country was contracted for.

Selling Construction Service by Mail

The Flynt Building & Construction Co. has obtained excellent results in soliciting business by correspondence. Some interesting information regarding this method is given by Mr. Charles F. Dingman, engineer at the New York office of the company, in an article in the February Contractor's Atlas, from which we quote as follows:

Under present day conditions the construction contract is not always awarded to the low bidder. Executives having charge of letting contracts have come to realize that there are more important factors of a contract than "price." They know from experience that many times the low bidder is the most poorly equipped for the work and the resulting construction proves very costly because of the inferior workmanship and materials which are ultimately discovered. Today, the contractor is selling a service, and if he will bear this fact in mind, it will soon be found that his services can be sold on the basis of reliability and speed and that price is a secondary consideration.

In fact, under present conditions, it is not at all unusual for a construction company to absolutely refuse to bid upon what appears to be an attractive contract and which covers work ardently desired by them. Nor is it very unusual for one company to get work without bidding, even though competing organizations are willing to bid sharply for the same work.

The truth is that purchasers of the services of building and construction organizations, like the public in general, have been educated to the point where they realize that a low price may often result in getting less return for their money than a higher price.

Because this is the truth, builders have come to realize that the proper way to sell their services is on the basis of quality and service, rather than on the basis of price, and the purpose of this article is to show how the mails may be used to aid in selling service. Aside from the use of the mails as a means of carrying general advertising inserted in newspapers and periodicals, there are two classes of direct mail advertising, either or both of which may be made to pay handsomely when properly and diligently worked.

The first class or direct mail advertising is that directed to persons whom we have reason to believe are, or soon will be, in the market for building services and the second class is that addressed to comparatively large lists of persons for the purpose of building up a reputation that will produce results later on as well as for discovering possible immediate prospective clients. The present article will discuss more particularly the first class.

As soon as the construction reports announce that a person is about to build, that person usually finds himself deluged with circulars and advertising matter of all kinds of building materials. He finds that all of the time which he had hoped to devote to other things is taken up in interviewing, or refusing interviews to building contractors who want to put in a figure or building material salesmen who want to be sure that their products are used in the building. Unless you are one of the first to see him, you find that he has begun to be so temperamental that it is difficult to conduct a pleasant interview with him. But—here is the point at which you can make the mails begin to work for you, don't go as an uninvited caller, but write the prospect a letter or letters that will make him want to see you and this is not so impossible as it may sound if you will only disregard the old cold and formal type of business letter and get right down to a man-to-man style.

To achieve this result your letter must open up with words that appeal to his own interest. Remember he is always thinking more about himself than he is about you or anyone else. Then let your letter tell him how his interests are going to be best conserved by employing you to do his work, tell him how pleased you will be to put at his disposal any facts or figures which your particular experience has enabled you to gather and which may be helpful to him in making up his program. Close the letter with a pleasant request that he invite you in to tell him just how you can serve him better than any of your competitors. If the first letter doesn't bring the invitation, send another and another until you get results or until the contract goes to some one else.

Now, I do not want to be understood as saying that letters should be used to the exclusion of other methods of soliciting business but I do want to say that they will, when properly used, save a great deal of time and expense that might be wasted otherwise, that they will often make it possible to secure interviews.

Of course, you will write many letters that will not bring replies, but, based upon carefully-kept records, I have found that in proportion to the results achieved the letter is the most profitable form of advertising that we have done, and as compared to general publicity in newspaper and periodicals, it has the advantage that the advertiser can control his circulation to suit himself.

Books As Tools

By E. A. GOEWAY,
Director Magazine Department, American Library Association.

Many far-seeing manufacturers and heads of business institutions have installed in their plants special libraries of technical books for the use of their workers, as well as for reference by themselves. From such libraries the worker may obtain books giving the most minute information upon the industry in which he is employed, and such books are in demand both during the lunch hour and for quiet reading at home. This plan is not a tentative scheme, but an established fact, and in such places as it has been followed it has met with the greatest favor on the part of both the employer and the worker. Among the great commercial and business institutions which have found that the installation of a special library of technical books was a wise step, might be mentioned: Marshall Field & Co., Chicago; B. F. Goodrich Co., Akron, O.; American Telephone & Telegraph Co., New York; Studebaker Corporation, South Bend, Ind.; National City Bank, New York; Winchester Repeating Arms Co., New Haven; Guaranty Trust Co., New York; National Cash Register Co., Dayton, O.; General Electric Co., Schenectady; Sears, Roebuck Co., Chicago; Curtis Publishing Co., Philadelphia; Philadelphia Commercial Museum; Chamber of Commerce of the United States, Washington; National Automobile Chamber of Commerce, New York, and The Merchants' Association, New York.

But there still is a deplorable lack of good libraries in business houses, shops, mills and manufactories when the country is considered as a whole. Every employer should be brought to see the benefits to be derived from these special libraries, and an important step toward this end has been taken by the American Library Association with its peace-time enlarged program, which is being carried out with the significant slogan, "Books for Everybody."

The enlarged program contemplates doing many things toward an even more general extension of the library service, emphasizing four outstanding features. One of these, and a very important one indeed, is with the aid of the Special Libraries Association to encourage a larger use of the technical books now in the public libraries and to urge employers of labor in factories and plants to install special libraries of technical books for the use of their employes.

To carry out its enlarged program the American Library Association will raise a fund of $2,000,000, not, however, by an intensive drive or campaign, but through the librarians, library trustees and friends of libraries.

The American Library Association was organized 44 years ago and has a membership of 4,000 active librarians. It will carry out its enlarged program in close co-operation with public libraries, library commissions and the Special Libraries Associations. These agencies already have done much toward encouraging the use of technical books by the men and women who have the most to gain by reading them and will continue their endeavors indefinitely. These agencies, however, earnestly seek the support of every employer throughout the country, that the effort may be successful.

Sixty Per Cent of People of U. S. Are Renters.—The 1920 census will probably show that 60 per cent of the people of the United States are living as tenants, says the president of the F. W. Dodge Co., New York, in a recent bulletin. France is said to have but 20 per cent of tenantry whereas the census of 1890 showed that [illegible] per cent of the people in the United States were tenants; in 1900 the percentage reached 55 per cent and in 1910, [illegible] per cent.

Some Advantages of the Fixed-Fee Contract for Building Construction*

By F. A. WELLS,
Vice-President and Treasurer, Wells Brothers' Construction Co., Chicago.

Is the general contractor to remain a constructive force in the building industry? We would hardly be attending this meeting were we not certain that the general contractor renders a needed service to the owner and architect and engineer. Certainty of delivery within the set time, reasonableness and the cost of construction, and the carrying out of plans and specifications without undue difficulty to owner or architect in getting that compliance, are dependent upon the existence of concerns such as are represented in the memberships of his association.

Yet there are certain individuals who see this matter differently; and who, noting certain things wrong, believe that the remedy is to be found in the elimination of the general contractor, and the assumption of his duties by the architect. What are some of these difficulties and what is the true answer? A well known middle west architect recently stated one side of the question in a letter to an architectural paper. That letter is significant to the members of this association as outlining a definite effort being made to get work done, without the general contractor. It started with the right premises. I do not feel however, that we as an organization or as individuals can agree with the conclusions. Let me quote:

"Curiously enough the architect has little or no direct dealings with the craftsman who executes his designs and the worst of it is that the head contractor is placed in a position in relation to the architect, which is the very opposite of what it should be to secure the ideal results for architecture.

"Our system of letting work by competitive bidding and then placing the contractor in a position where his profit depends largely on doing as little as the contract will allow for the final execution of the work is a vicious system which has always resulted in making impossible that sympathetic co-operation between architect, master builder and craftsman, which must exist in order to secure the best results in the work."

I think little explanation of this statement is necessary. We all know it to be true. It is a clear portrayal of the situation under the lump-sum contract. Regardless of the builder's ability, the amount remaining for profit is little or much, precisely according as the builder is fair or unfair, generous or tight in his interpretation of specifications.

But what is the answer? The author quoted has one idea and we have another. This architect goes on to say:

"An architectural firm with an architect at the head, a master builder and all of his assistants, including a competent force of skilled craftsmen to carry out sympathetically all of the details of the work, would make an organization which it must be admitted, would undoubtedly be far superior in every way to the organization it is at present necessary to gather together for every architectural problem undertaken."

I submit that the fixed-fee contract is a better solution of the problem. It requires that a reasonable fee be paid for a definite service.

Some architects may handle their clients' work through letting all operations to subcontractors and may accomplish a good result but there is no inherent necessity for the architect to broaden his scope. If he desires to increase his opportunity of making profit by extending his activities into the construction field it is unquestionably permissible, but to do so he must build a special construction organization able to do just what the general contractor now does, and candidly, most architects would prefer not to be responsible for the larger organization with its certain heavy overhead. In our judgment, after 40 years' experience with the various forms of building contracts, the cost-plus-fixed-fee contract, when made with a builder of integrity and ability, brings all that a fair-minded owner can expect or want.

Ability to co-ordinate work is fundamental to economy. It is second nature to the general contractor. While men available to the general contractor are also available to the architectural firm yet certain jobs going forward today where the architect handles all the work through subcontracts show very conclusively the lack of that co-ordination. A structure can not be erected piece meal, particularly in the case of concrete frame and floors. The continuance of identical operations over large areas is vital to economy. The synchronizing of subcontracts is equally important. If the orderly procession of work is not maintained someone is going to lose money or time or both. The subcontractor will not take that responsibility. The architect will do his best to co-ordinate all operations, but the owner holds the bag.

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*A paper presented Feb. 18 at the convention of the Associated General Contractors of America at Chicago.

We have, then, merely a merging of architectural and construction activities under one head. That co-ordination may be entirely successful but it does not argue against the general contractor continuing to operate to the advantage of the majority of owners and also of architects who prefer to remain within their chosen field.

Co-ordination means economy, and is dependent upon the absolute dovetailing of all trades represented with each other and particularly with the main structural elements. The framework could be built at least cost if no cognizance were taken of other trades. If that work is let as a separate contract there will be little sympathy on the part of the builder with delays occasioned by or to other trades. Such delays will be the basis for "extras." The better way is to have the structural frame handled by the same organization responsible for the general co-ordination of all work. Therefore the architectural firm handling construction should do exactly what the general contractor now does. But as a matter of fact, architectural firms do not, except in rare cases retain any part of the work for their own construction force to handle. Therefore such architect's service does not parallel the operations of the general contractor who does from 40 to 60 per cent of the work with his own organization and equipment.

But how will this contract meet our critic's objections? He wants the builder to operate with, instead of against, the architect. On the lump-sum basis there is a premium placed upon skinning the job and the multiplying of controverted interpretations of plans and specifications. Remove that premium and the difficulty disappears. The fixed-fee contract does it.

The "ideal result for architecture" consists in obtaining the best possible building at the lowest cost compatable with a reasonable time for execution. Now the best possible building is not reasonably to be expected where the builder can increase his profit by the amount of every omission or undetected substitution. Nor will there be a fine execution of the work where every minor opportunity for betterment of plans and in fact every necessity for change from original layout offers opportunity for extras on which few contractors have ever been known to suffer a loss. Under the fixed-fee plan it is possible to order changes, great or small, with absolute knowledge that the cost will be fair and often without increasing the amount of the fee.

Unquestionably the lump-sum system has many faults. It often gives opportunity for arbitrary and unfair rulings against the contractor, in favor of the owner. It kills that sympathetic co-operation between architect, master builder, craftsmen and owner, which should exist if the owner is to secure the best results. To revive that co-operation we need only to adopt the fixed-fee principle.

I quote from another well known architect writing also in the architectural press and answering a question propounded to the membership of the Illinois Society of Architects. That question was: "Can construction costs be lowered?" We are all interested in its solution. Let me quote him briefly.

"On first reading I was inclined to say that it cannot be done . . . . one method occurs to me. The idea I had concerns the letting of contracts. . . . . There are two methods, first: Letting separate contracts for each branch of the work on a unit price basis. Second: Letting a general contract for the entire work on the cost-plus-percentage basis. The latter method is the one I suggest . . . ." Quoting further:

"The question is largely one of buying power. The general contractor can buy and sublet so much cheaper than the architect that he saves not only his own percentage but in most cases considerably more . . . .

"The organized contractor's buying power is based on the same qualification as that of any business man who goes into the market to buy goods. He knows values and he knows the market. . . . .

"There is still another advantage. The element of divided interest is eliminated. The relation of owner, contractor and architect becomes one of co-operation solely, each striving for the best results at minimum cost. . . . ."

Thus we have heard from two architects. There is between them no middle ground. With the premises of the former we may agree, and with both the premises and conclusions of the latter we do agree.

Some of our members are strong partisans still of the lump-sum contract and desire the fixed-fee contract to be dropped. I believe however that under today's conditions the consensus of opinion of this organization, as well as of most owners, architects and engineers, is that the fixed-fee form of contract is wise and necessary.

The case might be different if we knew what carpenter labor would cost six weeks from today or whether cabinet work included in the contract will be delivered at an estimated figure or at a considerably increased cost, because of the almost impossibility of securing materials. Are contracts for certain materials worth the paper on which they are written? It is my understanding that certain of the smaller material manufacturers in one field have oversold their capacity several times and can deliver but a fraction of what they have contracted to deliver. Will they make good on their earlier low priced orders or on their later high priced contracts? What will we have to pay next summer when excuses take the place of shipments?

I believe these conditions are sufficient reason for the adoption of the cost-plus-fixed-fee contract by builders; for its approval by architects and engineers and for its acceptance by owners who are fair enough to expect to pay what their buildings really cost under capable and trustworthy management. We can do our utmost to safeguard an owner against undue cost but it is not our province to guarantee a cost unless we wish to enter into competition with Lloyd's. On the other hand, were the market falling, surely the owner would desire the advantage of possible lower costs.

The cost-plus-fixed-fee contract is just as adaptable to smaller sized jobs as to the largest construction work and the smaller contractors who are honest and capable can do work on this basis as readily as the larger contractors. The inefficient dishonest contractor, whether large or small, will be weeded out, and the standards of the building industry will inevitably be raised to much higher levels than would ever be possible under the lump-sum contract.

To me the vital necessity today is for this association to get behind the cost-plus-fixed-fee contract for building construction. General contractors will not lose by its adoption; they have much to gain. Architects and engineers have much to gain. Owners have much to gain.

For neither the owner nor his architect and engineer desires the cheapest building it is possible for a builder to erect under the plans and specifications. But that is exactly what he gets under the lump-sum contract. There can be no such thing as complete specifications. A lump-sum contract is a standing invitation to a builder to skimp the work just as far as he can get away with it.

Of course, a reliable contractor, jealous of his reputation, will not intentionally be unfair, and yet he is not able to look at a problem wholly from the standpoint of the owner if such an attitude jeopardizes his profit. Details not specifically covered in plans and specifications are frequently essential to the success of a building and the builder is not able under a lump-sum contract both to conserve his own interests and comply with the owner's wishes.

On the fixed-fee plan however, his profit is determined when the contract is signed and from that date he is seeking to erect the building speedily (so that he may release his organization to earn another fee) to erect it according to plans and specifications plus all later expressed wishes of architect and owner (in order that owner may again seek his service) and to erect it at the least cost compatible with the set standard of quality and speed in order that he may share in the savings.

Naturally the architect has an interest in these things. His work need be only that of interpreter, and not of watch dog.

Furthermore the fixed-fee contract permits work to proceed on the day the contract is signed. Construction may go on coincidentally with the development of details. If speed is paramount, the fixed-fee plan permits saving weeks and often months, required otherwise for completion of plans and specifications, quantity surveys, advertising for bids and final letting of contract. Under the lump-sum contract not one step can be taken until the contract is let on completed plans and specifications.

Occasionally a few dollars may be lost to an owner due to the later detailed plans necessitating changes in the preliminary construction but this seldom occurs.

An interesting comparison of results under the two methods of contracting has come to our attention. Last year, two competing mercantile concerns decided at about the same time to enter a new territory, and service could only start after new warehouses were erected. Two reputable general contractors were engaged, one upon the lump-sum and the other upon the fixed-fee basis. The lump-sum job, almost identical in size with the other, was started first but is not yet in service. The fixed-fee job was completed and in use in December. Owners of the latter advised architect and builder of the imperative need for speed and the successful outcome was the result, not of greater contracting ability, but of cooperation, trust and confidence on one job and its lack on the other, and the possibility under the fixed-fee contract of beginning work on the signing of the contract, of excavating while foundation plans were being prepared, and of keeping the work throughout, only one step behind the design.

But from the standpoint of the builder what are the benefits except as we share the satisfaction of owner and architect?

Do we not render a definite servcie for which we should be paid? Is it not well that we know with some certainty what a given operation is to net us? Is it not legitimate that we put our profession upon a service basis comparable to that of the architect and engineer? Building contracting firms are notoriously shortlived and the fault is not, we believe, in the lack of business ability so much as the system.

But a more fundamental reason exists than those previously mentioned. I believe that the reason that this association should go on record as favoring the fixed-fee contract is that it will eliminate from the field the dishonest builder. It will eliminate the organization which has not the ability to do successful work and that elimination will come about through the impossibility of that firm obtaining new business. Its record in the past will stand against it. Reputation is vital to a builder on fixed-fee operations. It is built up only through years of painstaking effort. It can be wrecked by a single operation. Therefore, dishonesty or lack of ability will promptly place a builder in such a position that he will be unable to stand investigation and therefore be unable to operate. There should be no room in the building field for other than able, conscientious builders.

Today's practice with some builders operating under the fixed-fee plan is to refuse to make preliminary estimates in competition. If owner and architect have not enough confidence and trust to make a contract subject to the builder's making a satisfactory estimate of probable cost, then they prefer not to serve, believing that they can do their best where the fullest confidence is reposed in them.

I sincerely believe that in these times of high building costs we can, through the fixed-fee plan, turn out a building at the absolute minimum cost. Costs are high at best. Legitimate projects are being passed up daily due to the difficulty of figuring a profit on the use of structures at today's costs. Cooperation, identity of interest and early covering in rising markets, permitted through the fixed-fee contract will help toward cost reduction.

I can only submit as further proof that the fixed-fee plan is right, the fact that my concern's history of repeat business is a surprise even to ourselves and adequate proof to us that such a basis is logical, fair and in harmony with the times.

Stationary Concreting Plant for Constructing 1,036 Ft. River Wall at Dayton

A stationary concrete plant having a number of interesting features is being employed by the Miami Conservancy District in constructing a retaining wall between 3rd and 5th sts. in Dayton, O. The new plant is described in the March Miami Conservancy Bulletin.

The necessities of enlarged capacity and improved alignment of the river bed lead to an unavoidable cutting in upon Robert boulevard and the adjacent valuable property. In order to reduce this to the lowest possible limits, it was advisable to substitute a concrete wall for the usual earth levee necessary to guard against overflow in flood seasons; thus saving the span occupied by the long land slope of a levee. The wall will have a total length of 1,036.4 ft. The total height is 25 ft.; the width of footing is 17 ft.; and the thickness at the top is 12 in. The wall is being built in 16-ft. sections, separated by vertical joints cutting through the entire wall, both neat work and footing, with a layer of asphalt between the sections. The work will require for completion some 4,500 cu. yd. of concrete. The design is of the semi-reinforced type, as giving maximum economy of construction.

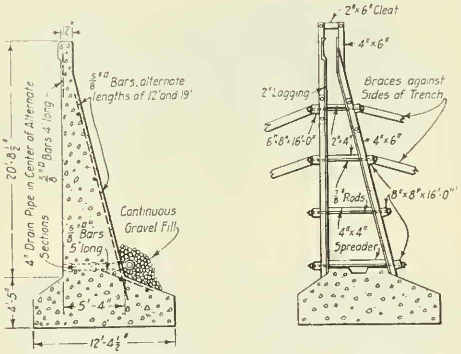


Fig. 1—Sections of Wall and Forms for Concrete.

Owing to the inaccessibility to a movable type of mixing plant in the crowded locality, in certain places, and also to eliminate the handling of the material at the mixer by hand, the stationary type of plant was adopted. The arrangements where the wall is under construction are shown in Fig. 2, the mixed materials being transported to this point from the mixer by dump cars, running on a narrow gage track. This figure gives the plan and elevation of the whole plant as it was at the beginning of the work.

The excavation for the wall is being carried to an average depth of about 20 ft., the bottom width being 14 ft. The excavation is made with a timber stiffleg derrick with 62 ft. steel boom. It has a 3-drum steam hoisting engine, is equipped with both dragline and clam shell buckets of 1-yd. capacity, and runs on skids and rollers. Excavation being inexpensive, little sheet piling is being used to enclose the excavation for the wall, the sides being carried up in earth at about a ½-to-1 slope, making the top width of the opening about 35 ft. In some places, where the trench runs close to buildings, sheet piling will also have to be used.

The general plan of the forms is indicated in Fig. 1. The lower form, for the footing, is not shown, being of the ordinary built-in-place type. The wall forms, as shown, are movable sectional forms, the two faces held apart by spreaders and clamped together by bolts and nuts. They are in 16-ft. lengths, corresponding to the sections in the wall, and are swung forward from section to section by derrick No. 2, which is a twin machine, practically, to derrick No. 1, already described. These wall forms are divided horizontally into two parts, permitting their adaptation to two slightly different proportions of the wall used in different localities; and permitting also an easier taking down and setting up of the sections, the latter 16 ft. by about 20 ft. in size, being rather bulky without division into pieces.

Derrick No. 2, besides handling the forms, does such backfilling behind the finished wall footing as is necessary to secure the earth under the narrow gage concreting track, the steep slope of the excavation, under thaw, sloughing off somewhat in places. Most of the back fill will be done more cheaply by a big dragline in the course of the regular river channel improvement. Derrick No. 2 also hoists and dumps concrete cars, which in case of the upper forms cannot chute the material directly into place.

The sand and gravel for the concrete are obtained from the bed of the river and are washed, screened and sorted in a plant situated on the river bank. From this plant the prepared materials are hauled in 5-ton motor-dump truck to the mixing plant at the work, where they are dumped into hoppers at the top of an incline, leading to bins for the sand and the aggregates. The sand runs from ¼ in. down; the fine gravel from ¼ to 1½ in.; and the coarse gravel from 1½ in. to 3 in. The bins hold about 15 cu. yd. each.

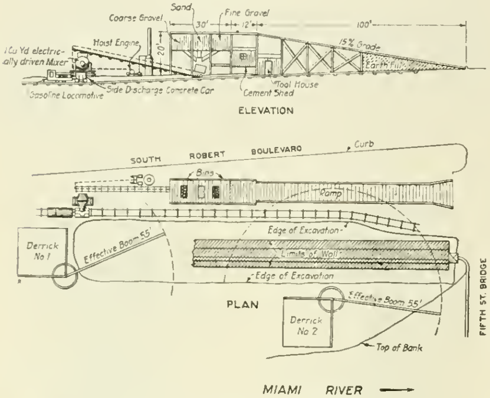


Fig. 2—Construction Plant Layout.

From the bins the materials are drawn through chutes into the bottom dump cars running on a track built at 15° incline, which leads to a platform over the mixer. Between the chutes and the car, measuring boxes are interposed, which permit the proper proportioning of the material. These proportions are 4 sacks cement to 9.6 cu. ft. of sand, to 10 cu. ft. each of the fine and the coarse gravel. This gives a 1:2:4:5 concrete.

The car is hauled up the incline by a single drum hoist engine, and dumps at the top into a hopper which holds one complete batch. This hopper is kept filled and ready at all times. From the hopper the batch is drawn into a Smith 1-yd. mixer, driven by a 7½ h.p. alternating current motor, and given a one-minute mix. From the mixer it is discharged into concrete cars running on a 3-ft. gage light railway leading alongside the wall excavation, whence it is discharged into the concrete forms. The cars are drawn by a 3-ton Plymouth gasoline dinkey.

The concrete cars are of two types. One is a side dump car, discharging its materials into the forms for the footing through a sloping chute. Materials for the upper part of the wall cannot be thus chuted, the wall top being on a level above that of the concrete track. In this case a bottom dump bucket of special form is used, riding on a small platform car, from which it is lifted by derrick No. 2 and dumped wherever wanted. Both types are of 1 cu. yd. capacity.

Most of the wall built to date has been poured in freezing weather. To meet this condition, the bins are warmed with steam pipes, two in each compartment, placed just above the bottom discharge gates. The water used in the mix is also heated in a wooden tank, by means of a steam coil. The boiler supplying steam for these pipes also feeds the hoist engine which pulls the cars of material up the inclined railway to the mixer. The concrete by the means described has been placed in the forms at a temperature not below 50° F. in the coldest weather. After being poured it has been protected by covering the entire form with tarpaulin, under which salamanders charged with coke are kept burning. With these precautions, no concrete has been frozen.

The design of this plant is due to Leslie Wiley, Superintendent of Construction on the District's railway work. The Dayton channel work is under the general direction of C. A. Bock, Division Engineer, E. I. Chandler, Assistant Division Engineer, and H. A. Hanson, Superintendent of Construction.

Method of Constructing Cofferdams for Key Bridge, Washington

An excellent example of cofferdam construction for bridge piers is afforded by the work now being carried out for the Key Bridge at Washington, D. C. The work is described by John T. Tolman, Assistant Engineer, U. S. Engineer Department at Large, in The Military Engineer, to which we are indebted for the matter that follows:

The bridge is to extend across the Potomac River from Georgetown, D. C., to Rosslyn, Va. It is being built by the U. S. Government to replace the old aqueduct bridge, is to be a concrete-arch bridge composed of seven spans varying in length from 85 to 208 ft. The total length of the bridge, including approaches, will be about 2,700 ft., and the length of the masonry structure proper about 1,450 ft.

The width of the deck from out-to-out will be 70 ft. 6 in., which allows for a double-track electric line, two 16-ft. roadways and two 8-ft. sidewalks.

The bridge will also be provided with two conduits located under the sidewalks in which cables, gas and water mains, etc., may be laid. The height of the deck of the bridge at mid-stream will be about 85 ft. above mean low water, which will give an under clearance of 72 ft. at the center span.

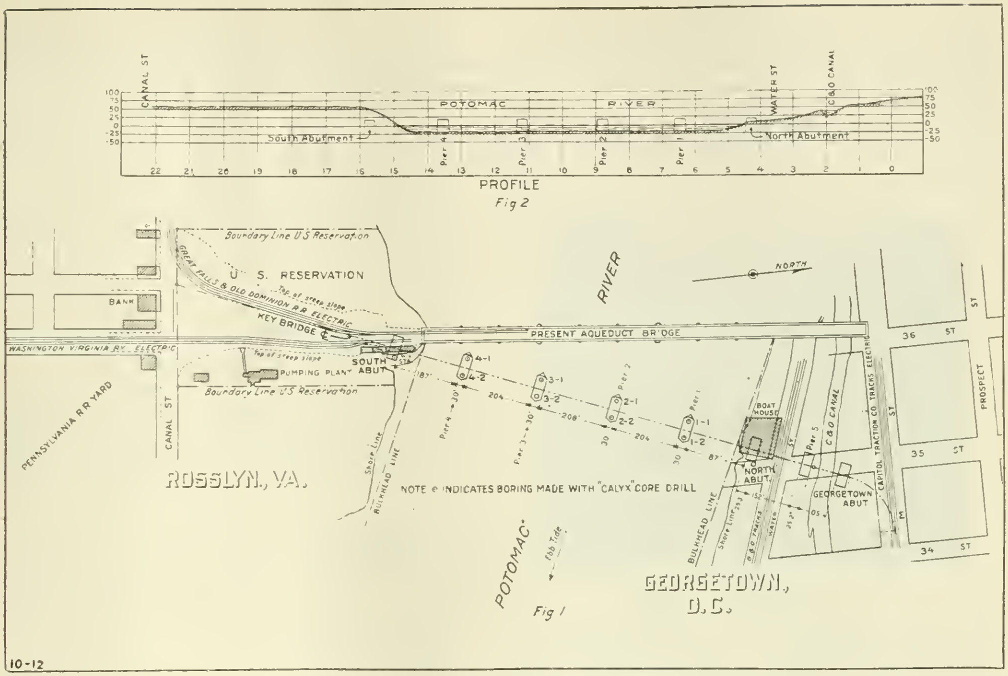
The plan shows alignment of the bridge and location of the four river piers. These piers are designed as abutment piers and are being founded upon solid rock. Prior to construction careful examinations were made of the foundations at the site of each pier and abutment.

This examination consisted of a series of soundings and probings taken on, and parallel to, the center line of the proposed structure from shore to shore. After the spans were decided upon, a floating template, the size of the proposed cofferdams, was placed at each pier position and three sets of soundings and probings were made around it. Borings were also made at each end of each pier position and a core removed to a depth of 20 ft. into the rock.

Cofferdam Frame on Ways Ready for Launching.

The depth of water at these pier locations varies from 24 to 35 ft. at mean low water, the average tide being about 2.9 ft. Floods in this river are not frequent, are of short duration and seldom raise the water level more than 6 ft. above M. L. W.

The method of constructing these piers was given most careful study and it was finally decided to build them in open cofferdams. These cofferdams are timber frames surrounded by steel sheeting sealed to the rock bottom. The timber



Location, Plan and Profile of New Key Bridge.

frames were erected on the Virginia shore upon launching-ways. They are 103 ft. long, 45 ft. wide and 24 ft. deep, and composed of three longitudinal trusses 101 ft. long and 24 ft. deep, separated by series of 12 by 12 timbers, and two end-trusses 45 ft. long and 24 ft. deep, all connections being through-bolted. The reason for trussing these frames was to give them greater rigidity and prevent any chance of distortion in handling them from the ways to their location in the river.

These frames are supported upon nine shoes about 12 ft. long, 3 ft. wide and 2 ft. high, each furnished with two sets of cast-iron rollers connected by steel axles. The rollers turn in grooves cut in the bottom of the shoes and drop off as the frame leaves the ways. They are later recovered and used again under the next frame. The rollers run in 7-in. channels spiked to the timber-ways. The shoes also function when the frame is in place by holding the lower timbers off the uneven bottom, thereby making it easier to level-up the frame.

These frames, after being launched, were lifted clear of the bottom by means of a scow at each end, and towed to their proper locations.

After being lowered into position and blocked up level by a diver, their height was increased 10 ft. by superposing additional frames.

The sheetings of these coffers consists of ordinary 12-in. 31½-lb. I-beams interlocked into two 7-in. channels, separated by wood filler blocks 5⅛-in. by 5⅛-in. in section, securely bolted together

The sheeting was placed by a derrick-boat with swinging pile-driver leads. The sheets required very little hammering to force into place, as the small amount of mud that overlaid the rock had been removed by dredging prior to the placing of the frame. The only driving that was necessary was enough to overcome the friction of the interlock; many sheets dropping to place of their own weight.

A diver watched the sheets at the bottom to see that they hugged the frame and about every fifth sheet was secured to the frame at the top. About fifty sheets were placed in a single day of 8 hours. At the corners 12-in. I-beams, bent 90 degrees, were used. The closures were formed by using wide channels bolted together and filled with concrete after being driven. Practically all the steel employed as sheeting will be used later in the construction of the deck of the bridge.

The sealing of these dams was done by divers, and consisted in placing a sand-bag wall around the outside of the dam, about 4 ft. from the steel. The top of this wall was brought up about 2 ft. above the bottom of the steel sheets. The rock bottom of the trench formed by the bag wall and the walls of the dam was cleared of mud, sands, etc., by the use of an air jack or siphon.

An air-jack is a long piece of 6-in. malleable pipe with a small air-pipe leading down outside to the bottom of the larger pipe and turned up into it. The jack is floated at its upper end just above the water and the air or operating end is moved from place to place by the diver. Compressed air is forced down the air-pipe into the base of the jack-pipe and lifts water, sand, mud, and even large cobbles to the discharge end. It is in effect a siphon.

As soon as the trench had been thoroughly cleaned, wedge-shaped forms, about 12 in. deep, were placed all around the dam, the forms being suspended by wires with their tops at the same level as the top of the bag wall. The trench was then filled with concrete placed through a trémie on a scow, the movements of the trémie being regulated by the diver. As soon as this concrete had set-up sufficiently, the wedge-shaped forms were removed and this groove was packed with a row of sand-bags. Upon these sand-bags rolling mats were placed. These were composed of canvas in long rolls, filled with straw, old burlap, manure and such other materials as could be secured at the time. The mats were about 12 in. in diameter with a flap 3 or 4 ft. long. These rolling mats were placed as close to the steel as possible with the flap extending out over the concrete seal and weighted down with sand-bags.

The object of this pliable wedge was to take up the give in the timber frame caused by the pressure developed during dewatering. This inward movement would cause a crack to develop between the steel sheeting and the concrete seal.

As soon as the seal was perfected the pumps were started and cinders were dropped in small quantities down the outside of the sheeting. These cinders were drawn into any small leak that developed either in the sheeting or in the seal. The seal was then tested out for some time before any mud was banked around the dam, and on the dam just dewatered a head of about 15 ft. was secured without any banking.

When the pumps had produced sufficient head on the dam the diver made an examination of the seal and, at the same time, an examination was made by the use of a current-meter inside the dam to detect the location of leaks. These leaks are usually caused by sand or gravel deposits in rock seams, and may extend far out from the dam. The hardest leaks to detect are bottom leaks. So far they have given no trouble in these dams, but there is kept on hand a compressed-air grouting machine ready to meet such a condition should it arise.

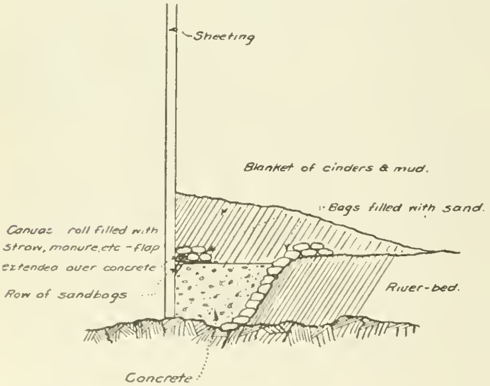
Bottom of Pier 4, Showing Rock Foundation.

After the test of the seal, a mud bank from 6 to 10 ft. high was placed around the dams.

The pumps used were two pulsometers and one Emerson steam pump. The Emerson pump has a capacity of 2,000 gal. per minute, one pulsometer 2,200 gal. and the second 750 gal. per minute. The steam for these pumps is supplied from two 125-h.p. portable boilers, mounted upon a scow.

Three dams have already been placed and pumped out. The shortest time required to dewater a dam was in the case of No. 3, which was eleven days from the time the pumps were started. No. 1 dam required four weeks and No. 4 required 6 weeks.

Immediately after the dams had been dewatered, forms were placed 2 ft. inside the lower wales, the rock thoroughly cleaned off and an inner concrete sealing ring placed. This ring extends from the rock to the under side of the lower wale and canvas was placed wherever possible against the steel sheeting to prevent the concrete from bonding with the steel and making the pulling of the sheeting difficult.


Sheeting
Blanket of cinders & mud.
Bags filled with sand.
Canvas roll filled with straw, manure, etc - flap extended over concrete
Row of sandbags
River-bed.
Concrete

Method of Sealing Cofferdam.

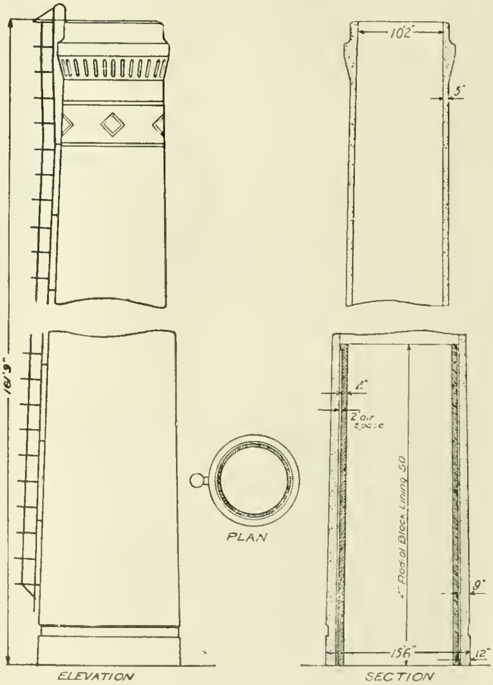
Wherever lateral leaks existed, the water was carried through the inner seal by wood boxes or conduits, the concrete being poured around them, and when the concrete had set the conduits were plugged.

When the inner seal was completed the sealing forms were removed and the entire bottom of the dam was thoroughly cleared of mud and loose or disintegrated rock, and the surface scoured. The foundation was then ready for the base course of the pier which was poured up to the lower waling timbers. Above this point forms were set up and the pier was poured in the form of blocks 12 ft. high between the timbers. When these blocks had set, the pressures on the lower section of the dams were taken by strutting against them and the lower inner timbers were removed. The space between the blocks was then filled with concrete and this process was continued to the top of the dam.

It has been found that the steel sheeting in these dams pulls remarkably well and is in excellent shape after using Dam No. 4 was pulled and the steel redriven around Dam No. 3 without the loss of a single sheet and the frame re-erected for Dam No. 2, there being but few broken timbers requiring renewal.

An Unusual Concrete Chimney Construction

An unusual method of obtaining the required height for a chimney was described by Harry M. Hope in the January issue of the "Contractor's Atlas." The two large concrete chimneys of the Montville Power Station of the Eastern Connecticut Power Co., at Montville, Conn., were erected directly on the top of the power house. A 250-ft. height was obtained and a substantial financial saving, as well as one of considerable ground space, was made.



Section and Elevation Views of Chimney.

The chimneys measure approximately 160 ft. above the roof level, which is 90 ft. above the ground. They have an outside diameter of 15 ft. 6 in. at bottom and 11 ft. at the top. The minimum inside diameter is 10 ft. A 4-in. fire brick lining is used in the lower 50 ft.

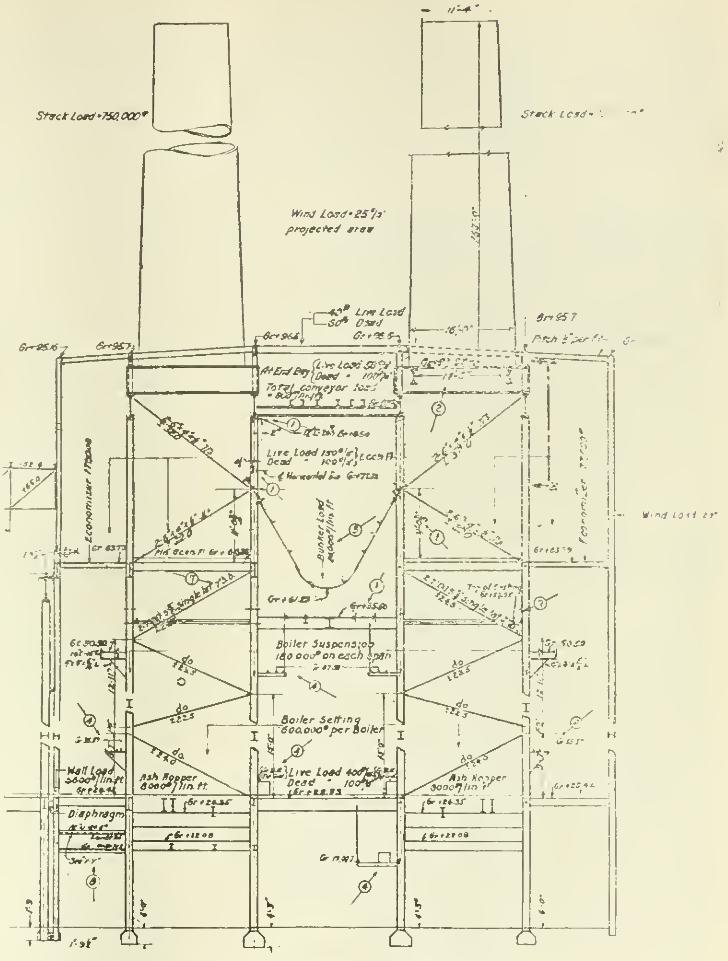
Each chimney rests on an annular concrete mat 18 in. thick which is placed on an octagonal frame of steel girders. The girders are supported on the building columns. 1¼-in. diameter steel rods spaced approximately 18 in. on center, anchor the lower sections of the chimneys securely to the girders.

The design of the chimney supports presented a difficult structural problem as space requirements of the equipment interfered with the proper structural arrangement of the columns and wind bracing. The final solution of the problem satisfied both the clearance and structural requirements.

By super-imposing the chimneys on the building saving was made by eliminating the long run of exposed flue which would have been necessary to reach chimneys located on the ground outside of the building.

The roof slab is not connected with the chimneys but terminates in a curb 6 in. away from the outside of the chimney. A concrete apron overlapping the curb was cased in a recess left in the chimneys. The space between the roof slab and the chimney was utilized for ventilation, the heat of the flue furnishing positive circulation. This feature has worked out very successfully.

The chimneys were designed by the Harry M. Hope Engineering Co., Boston, Mass., and were built in accordance with the standard practice of the sub-contractors, The Heine Chimney Co., of Chicago, Ill., using its steel forms and form centering method.


Stack Load=750,000#
Wind Load=25#/□' projected area
40# Live Load
50# Dead
At End Bay {Live Load 50#/□' Dead = 100#/□'
Total conveyor load
Live Load 150#/□' Dead = 100#/□'
Economizer
Bunker Load
Boiler Suspension 180 000# on each span
Boiler Setting 600,000# per Boiler
Wall Load 3000#/lin. ft.
Ash Hopper 8000#/lin. ft.
Live Load 400#
Dead = 100#
Ash Hopper 8000#/lin. ft.
Diaphragm
Wind Load 25#

Detailed Drawing Showing Design Features.

Wages in the Lumber Industry.—A table giving relative earnings per hour in eight industries, 1913 to 1919, on a basis of 100 per cent for 1913, just published by the Bureau of Labor Statistics, shows that employes in the lumber industry have received increases in earnings considerably in excess of the average for the eight industries, and in excess of the increase in the cost of living since 1913. The millwork and furniture industries, however, had in 1919 not kept pace with the general movement. The eight industries are cigar-making, in which in 1919, wages were 52 per cent higher than those in 1913; clothing, 71 per cent higher; furniture, 54 per cent; hosiery and underwear, 84 per cent; iron and steel, 121 per cent; lumber, 94 per cent; millwork, 51 per cent, and silk goods, 91 per cent. The average actual earnings per week of band sawyers in 1919 ranges from $55.03 in Louisiana and $54.98 in Oregon, to $30.96 in West Virginia; the actual working hours per week of the first group being 58.1; of the second 47.4 hours and of the third, 48 hours. The largest average number of actual hours worked by band sawyers was in Wisconsin—60.6 hours per week for $38.84; the lowest, 42.6 hours in Alabama at an average wage of $33.27, according to the Bureau. These figures are based on returns from 141 establishments and 18,022 employes in practically every lumber state in the country and in all months of the year. The lumber occupations tabulated are doggers, edgermen, laborers, machine feeders, band sawyers and setters. In comparison with 1913 figures, it is interesting to note that although sawyers are the best paid, the increase in wages over 1913 is largest for laborers and machine feeders; their full time weekly earnings in 1919 being respectively 84.9 per cent and 86.3 per cent higher than 1913 wages. Band sawyers in 1919 received 28.9 per cent more than they earned in 1913. In 1915 wages in all occupations in the industry tabulated, were low, showing only 91.5 per cent of the 1913 wages. In the same year, lumber prices were relatively still lower.

The Length of Wood Fibers

The current supposition that each species of wood has a characteristic fiber length is not borne out by the many thousand measurements which have been made at the Forest Products Laboratory on wood fibers. These measurements show that a greater difference may be found in one tree than exists between the average fiber lengths of different species. In one Douglas fir disc, for example, the fibers varied from .8 to 7.65 millimeters (.03 to .3 in.) in length, which is a variation of nearly 7 millimeters. On the other hand, the averages of several thousand measurements on Douglas fir and longleaf pine were less than one millimeter apart, being 4.41 and 3.67 millimeters, respectively. In the first case, 67 per cent of the fiber measurements in one tree fell between 4.5 and 6.5 millimeters, which roughly indicates the meaning of the common term "average fiber length" for the tree or species. Such data obviously can be of little value for identification purposes, because of the overlapping of the ranges of fiber length in the various species. Some relations have been observed between the length of fibers and their position in the tree. During the first 20-50 years of growth, the increase in fiber length from the center of a tree outward in any plane is very striking. An approximate maximum having been attained, fiber length, though it may fluctuate somewhat, does not radically change thereafter, even in trees 400 or more years old.

"

Important Points in the New Railroad Law

The railroad reorganization bill, reported to both houses of Congress by the conference committee on February 18, and later passed by both houses was approved by the President on the 28th, thereby becoming a law. This formidable document of 48 pages represents the almost continuous work of the congressional committees for a period of several months, and the result has been a piece of legislation which will be of far-reaching importance. Critics in and out of Congress have disagreed with some of the bill's provisions, but nevertheless it is conceded by disinterested people who have made a study of it that it will rank with one of the most constructive pieces of legislation ever passed by Congress. Certainly a mere casual reading of the Act will give an unbiased reader increased respect for the legislators who have been able to frame this law to meet a sore need.

As indicated in the title, the Act not only provides for the termination of Federal control of railroads and systems of transportation, but provides for the settlement of disputes between carriers and their employes, and also has to do in a very large way with the amendment of the original Interstate Commerce Act of February 4, 1887, with its amendments.

In what follows, no attempt has been made to make a complete or comprehensive resumé of this so-called "Transportation Act," but merely by quotation or otherwise, to call attention to certain points which stand out as being of special interest or importance.

Nothing in this act shall be construed as affecting or limiting the power of the President in time of war (under section 1 of the act entitled "An act making appropriations for the support of the Army for the fiscal year ending June 30, 1917, and for other purposes," approved August 29, 1916) to take possession and assume control of any system of transportation and utilize the same.

The President shall have the right, at all reasonable times until the affairs of federal control are concluded, to inspect the property and records of all carriers whose railroads or systems of transportation were at any time under federal control, whenever such inspection is necessary or appropriate (1) to protect the interests of the United States, or (2) to supervise matters being handled for the United States by agents or the carriers, or (3) to secure information concerning matters arising during federal control, and such carriers shall provide all reasonable facilities therefor, including the issuance of free transportation to all agents of the President while traveling on official business for these purposes.

Such carriers shall, at their expense, upon the request of the President, or those duly authorized by him, furnish all necessary and proper information and reports compiled from the records made or kept during the period of federal control affecting their respective lines, and shall keep and continue such records and furnish information and reports compiled therefrom.

All rates, fares and charges, and all classifications, regulations and practices, in any wise changing, affecting or determining any part or the aggregate of rates, fares or charges, or the value of the service rendered, which on February 29, 1920, are in effect on the lines of carriers subject to the Interstate Commerce Act, shall continue in force and effect until thereafter changed by state or federal authority, respectively, or pursuant to authority of law; but prior to September 1, 1920, no such rate, fare or charge shall be reduced, and no such classification, regulation or practice shall be changed in such manner as to reduce any such rate, fare or charge, unless such reduction or change is approved by the Commission.

For a "guaranty period" of six months, beginning with March 1, 1920, the government guarantees the railway operating income of the carriers shall be not less than one-half the amount named in the "Federal Control" Act of March 21, 1918.

For the purpose of enabling carriers by railroad subject to the Interstate Commerce Act properly to serve the public during the transition period immediately following the termination of federal control, any such carrier may, at any time after the passage of this act and before the expiration of two years after the termination of federal control, make application to the Commission for a loan from the United States, setting forth the amount of the loan and the term for which it is desired, the purpose of the loan and the uses to which it will be applied, the present and prospective ability of the applicant to repay the loan and meet the requirements of its obligations in that regard, the character and value of the security offered, and the extent to which the public convenience and necessity will be served. The application shall be accompanied by statements showing such facts and details as the Commission may require with respect to the physical situation, ownership, capitalization, indebtedness, contract obligations, operation, and earning power of the applicant, together with such other facts relating to the propriety and expediency of granting the loan applied for and the ability of the applicant to make good the obligation, as the Commission may deem pertinent to the inquiry.

There is hereby appropriated out of any moneys in the Treasury not otherwise appropriated the sum of $300,000,000, which shall be used as a revolving fund for the purpose of making loans.

* * * *

There is hereby established a board to be known as the "Railroad Labor Board" and to be composed of nine members, as follows:

(1) Three members constituting the labor group, representing the employees and subordinate officials of the carriers, to be appointed by the President, by and with the advice and consent of the Senate, from not less than six nominees whose nominations shall be made and offered by such employees in such manner as the Commission shall by regulation prescribe;

(2) Three members, constituting the management group, representing the carriers, to be appointed by the President, by and with the advice and consent of the Senate, from not less than six nominees whose nominations shall be made and offered by the carriers in such manner as the Commission shall by regulation prescribe; and

(3) Three members, constituting the public group, representing the public, to be appointed directly by the President, by and with the advice and consent of the Senate.

Of the original members of the Labor Board, one from each group shall be appointed for a term of three years, one for two years, and one for one year. Their successors shall hold office for terms of five years, except that any member appointed to fill a vacancy shall be appointed only for the unexpired term of the member whom he succeeds. Each member shall receive from the United States an annual salary of $10,000. A member may be removed by the President for neglect of duty or malfeasance in office, but for no other cause.

The Labor Board shall hear, and as soon as practicable and with due diligence decide, any dispute involving grievances, rules or working conditions, in respect to which any adjustment board certifies to the Labor Board that in its opinion the adjustment board has failed or will fail to reach a decision within a reasonable time, or in respect to which the Labor Board determines that any adjustment board has so failed or is not using due diligence in its consideration thereof. In case any adjustment board is not organized under the provisions of section 302, the Labor Board, (1) upon the application of the chief executive of any carrier or organization of employees or subordinate officials whose members are directly interested in the dispute, (2) upon a written petition signed by 100 unorganized employees or subordinate officials directly interested in the dispute, or (3) upon the Labor Board's own motion if it is of the opinion that the dispute is likely substantially to interrupt commerce, shall receive for hearing, and as soon as practicable and with due diligence decide, any dispute involving grievances rules or working conditions.

A very important provision concerning the decisions of the Labor Board is that a decision relating to wages or salaries of employes shall have the concurrence of at least 5 of the 9 members of the board, and that at least one of the representatives of the public shall concur in such decision (at last the public has some official standing!).

In determining the reasonableness and justness of wages and salaries, the board is enjoined to take into consideration

(1) The scale of wages paid for similar kinds of work in other industries;

(2) The relation between wages and the cost of living;

(3) The hazards of the employment;

(4) The training and skill required;

(5) The degree of responsibility;

(6) The character and regularity of the employment; and

(7) Inequalities of increases in wages or of treatment, the result of previous wage orders or adjustments.

The central offices of the Labor Board are to be in Chicago.

As stated above, a large part of the "Transportation Act" is devoted to amendments of the "Interstate Commerce Act." Generally speaking the powers of the Interstate Commerce Commission have been considerably enlarged.

Whenever the Commission is of opinion that shortage of equipment, congestion of traffic, or other emergency requiring immediate action exists in any section of the country, the Commission shall have, and it is hereby given, authority, either upon complaint or upon its own initiative without complaint, at once, if it so orders, without answers or other formal pleading by the interested carrier or carriers, and with or without notice, hearing or the making or filing of a report, according as the Commission may determine: (a) to suspend the operation of any or all rules, regulations or practices then established with respect to car service for such time as may be determined by the Commission; (b) to make such just and reasonable directions with respect to car service without regard to the ownership as between carriers of locomotives, cars and other vehicles, during such emergency as in its opinion will best promote the service in the interest of the public and the commerce of the people, upon such terms of compensation as between the carriers as they may agree upon, or, in the event of their disagreement, as the Commission may after subsequent hearing find to be just and reasonable; (c) to require such joint or common use of terminals, including main-line track or tracks for a reasonable distance outside of such terminals, as in its opinion will best meet the emergency and serve the public interest, and upon such terms as between the carriers as they may agree upon or, in the event of their disagreement, as the Commission may after subsequent hearing find to be just and reasonable; and (d) to give directions for preference or priority in transportation, embargoes or movement of traffic under permits, at such time and for such periods as it may determine, and to modify, change, suspend or annul them. In time of war or threatened war the President may certify to the Commission that it is essential to the national defense and security that certain traffic shall have preference or priority in transportation, and the Commission shall, under the power herein conferred, direct that such preference or priority be afforded.

After ninety days after this paragraph takes effect no carrier by railroad subject to this act shall undertake the extension of its line of railroad, or the construction of a new line of railroad, or shall acquire or operate any line of railroad, or extension thereof, or shall engage in transportation under this act over or by means of such additional or extended line of railroad, unless and until there shall first have been obtained from the Commission a certificate that the present or future public convenience and necessity require or will require the construction, or operation, or construction and operation, of such additional or extended line of railroad, and no carrier by railroad subject to this act shall abandon all or any portion of a line of railroad, or the operation thereof, unless and until there shall first have been obtained from the Commission a certificate that the present or future public convenience and necessity permit of such abandonment.

The commission is directed, upon complaint, or upon its own initiative, to authorize or require by order any carrier to provide itself with safe and adequate facilities for performing its car service and also to extend its line or lines, if it finds that such is reasonably required in the interest of public convenience and necessity, without impairing the ability of the carrier to perform its duty to the public.

If the Commission finds it to be in the public interest and to be practicable, without substantially impairing the ability of a carrier owning or entitled to the enjoyment of terminal facilities to handle its own business, it shall have power to require the use of any such terminal facilities, including main-line track or tracks for a reasonable distance outside of such terminal, of any carrier, by another carrier or carriers, on such terms and for such compensation as the carriers affected may agree upon, or, in the event of a failure to agree, as the Commission may fix as just and reasonable for the use so required, to be ascertained on the principle controlling compensation in condemnation proceedings. Such compensation shall be paid or adequately secured before the enjoyment of the use may be commenced. If under this paragraph the use of such terminal facilities of any carrier is required to be given to another carrier or carriers, and the carrier whose terminal facilities are required to be so used is not satisfied with the terms fixed for such use, or if the amount of compensation so fixed is not duly and promptly paid, the carrier whose terminal facilities have thus been required to be given to another carrier or other carriers shall be entitled to recover, by suit or action against such other carrier or carriers, proper damages for any injuries sustained by it as the result of compliance with such requirement, or just compensation for such use, or both, as the case may be.

Whenever the Commission is of opinion, after hearing, upon application of any carrier or carriers engaged in the transportation of passengers or property subject to this act, that the acquisition, to the extent indicated by the Commission, by one of such carriers of the control of any other such carrier or carriers either under a lease or by the purchase of stock or in any other manner not involving the consolidation of such carriers into a single system for ownership and operation, will be in the public interest, the Commission shall have authority by order to approve and authorize such acquisition, under such rules and regulations and for such consideration and on such terms and conditions as shall be found by the Commission to be just and reasonable in the premises.

The Commission shall as soon as practicable prepare and adopt a plan for the consolidation of the railway properties of the continental United States into a limited number of systems. In the division of such railways into such systems under such plan, competition shall be preserved as fully as possible and wherever practicable the existing routes and channels of trade and commerce shall be maintained. Subject to the foregoing requirements, the several systems shall be so arranged that the cost of transportation as between competitive systems and as related to the values of the properties through which the service is rendered shall be the same, so far as practicable, so that these systems can employ uniform rates in the movement of competitive traffic and under efficient management earn substantially the same rate of return upon the value of their respective railway properties.

In the exercise of its power to prescribe just and reasonable rates the Commission shall initiate, modify, establish or adjust such rates so that carriers as a whole (or as a whole in each of such rate groups or territories as the Commission may from time to time designate) will, under honest, efficient and economical management and reasonable expenditures for maintenance of way, structures and equipment, earn an aggregate annual net railway operating income equal, as nearly as may be, to a fair return upon the aggregate value of the railway property of such carriers held for and used in the service of transportation: Provided, That the Commission shall have reasonable latitude to modify or adjust any particular rate which it may find to be unjust or unreasonable, and to prescribe different rates for different sections of the country.

The Commission shall from time to time determine and make public what percentage of such aggregate property value constitutes a fair return thereon, and such percentage shall be uniform for all rate groups or territories which may be designated by the Commission. In making such determination it shall give due consideration, among other things, to the transportation needs of the country and the necessity (under honest, efficient and economical management of existing transportation facilities) of enlarging such facilities in order to provide the people of the United States with adequate transportation: Provided, That during the two years beginning March 1, 1920, the Commission shall take as such fair return a sum equal to 5½ per centum of such aggregate value, but may, in its discretion, add thereto a sum not exceeding one-half of one per centum of such aggregate value to make provision in whole or in part for improvements, betterments or equipment, which, according to the accounting system prescribed by the Commission, are chargeable to capital account.

If, under the provisions of this section, any carrier receives for any year a net railway operating income in excess of 6 per centum of the value of the railway property held for and used by it in the service of transportation, one-half of such excess shall be placed in a reserve fund established and maintained by such carrier, and the remaining one-half thereof shall, within the first four months following the close of the period for which such computation is made, be recoverable by and paid to the Commission for the purpose of establishing and maintaining a general railroad contingent fund as hereinafter described.

A carrier may at any time make application to the Commission for a loan from the general railroad contingent fund, setting forth the amount of the loan and the term for which it is desired, the purpose of the loan and the uses to which it will be applied, the present and prospective ability of the applicant to repay the loan and meet the requirements of its obligations in that regard, the character and value of the security offered, and the extent to which the public convenience and necessity will be served. The application shall be accompanied by statements showing such facts and details as the Commission may require with respect to the physical situation, ownership, capitalization, indebtedness, contract obligations, operation and earning power of the applicant, together with such other facts relating to the propriety and expediency of granting the loan applied for and the ability of the applicant to make good the obligation, as the Commission may deem pertinent to the inquiry.

A carrier may at any time apply to the Commission for the lease to it of transportation equipment purchased from the general railroad contingent fund, setting forth the kind and amount of such equipment or facilities and the term for which it is desired to be leased, the uses to which it is proposed to put such equipment or facilities, the present and prospective ability of the applicant to pay the rental charges thereon and to meet the requirements of its obligations under the lease, and the extent to which the public convenience and necessity will be served.

The Commission may from time to time purchase, contract for the construction, repair and replacement of, and sell, equipment and facilities, and enter into and carry out contracts and other obligations in connection therewith, to the extent that moneys included in the general railroad contingent fund are available therefor, and in so far as necessary to enable it to secure and supply equipment and facilities to carriers whose applications therefor are approved under the provisions of this section, and to maintain and dispose of such equipment and facilities.

Any carrier, or any corporation organized to construct and operate a railroad, proposing to undertake the construction and operation of a new line of railroad may apply to the Commission for permission to retain for a period not to exceed ten years all or any part of its earnings derived from such new construction in excess of the amount heretofore in this section provided, for such disposition as it may lawfully make of the same, and the Commission may, in its discretion, grant such permission: conditioned, however, upon the completion of the work of construciton within a period to be designated by the Commission in its order granting such permission.

After December 31, 1921, it shall be unlawful for any person to hold the position of officer or director of more than one carrier, unless such holding shall have been authorized by order of the Commission, upon due showing, in form and manner prescribed by the Commission, that neither public nor private interests will be adversely affected thereby.

The Commission is hereby enlarged so as to consist of eleven members, with terms of seven years, and each shall receive $12,000 compensation annually. The qualifications of the members and the manner of payment of their salaries shall be as already provided by law. Such enlargement of the Commission shall be accomplished through appointment by the President, by and with the advice and consent of the Senate, of two additional Interstate Commerce Commissioners, one for a term expiring December 31, 1923, and one for a term expiring December 31, 1924. The terms of the present commissioners, or of any successor appointed to fill a vacancy caused by death or resignation of any of the present commissioners, shall expire as heretofore provided by law. Their successors and the successors of the additional commissioners herein provided for shall be appointed for the full term of seven years, except that any person appointed to fill a vacancy shall be appointed only for the unexpired term of the commissioner whom he shall succeed. Not more than six commissioners shall be appointed from the same political party. Hereafter the salary of the secretary of the Commission shall be $7,500 a year.

It will be seen from the foregoing rather incomplete resumé of this important act of Congress that, as never before, the rights of the public, the railway ownership and management, and the railway employes, have been recognized, and an honest attempt made to define and ensure these rights. A period of transition and readjustment in the next few months is inevitable, but before very long the public will have the right to expect very substantial improvements in facilities and in service. It is believed that railway managements and railway employes, will, in general, be kindly disposed towards the new regulations, and will be willing to do what is in their power to enable a fair trial of them to be made.

New Lumber Association Formed.—Leading wholesale lumber dealers of the United States have organized the American Lumber Association, with headquarters in Chicago. The purposes of the association are to standardize the buying and distribution of lumber, to enforce a rigid code of business ethics among lumber wholesalers and to systematize distribution. L. R. Putnam, of New Orleans, is manager of the association.

News Letter

St. Louis Items

Ralph Thomas, of the C. R. Cummins Co., was here the other day.

J. W. Skinner, one of the good old time contractors, is now at Caseyville, Ill., with the Alunite Chemical Co.

The Modern Contracting & Supply Co. were awarded a percentage job by the Walsh Fire Clay Co. near Vandalia, Mo.

R. T. Amis was awarded a contract for building a reservoir for the city of Guthrie Okla. Expects to finish this in 60 days.

Pat Hannan returned from Ft. Smith, Ark. Reports that his job on the Ft. Smith, Sabiuca & Rock Island R. R. is near completion.

N. J. Urquhart, 4052 Delmar avenue, St. Louis, Mo., is in the market for some concrete work. He also has several oil derricks idle now.

Jim Austin came in from his farm at Benton, Ill. Would not be a bit surprised to see Jim breaking into the contracting game before long.

List & Gifford Constr. Co. are moving a steam-shovel outfit on a new job that was awarded to them by the Missouri Pacific R. R. near Dupo, Ill.

Bates & Rogers Const. Co. Mason City, Ill., have 25,000 yds. of team work to let near there. Write C. R. E. Ross, superintendent in charge of this work.

The Jacob Schaefer Wrecking & Excavating Corporation, 1080 Easton Ave., St. Louis, Mo., has 31,000 yds. of wheeler work near Springfield, Ill., to sublet.

A. L. Cook, Ottawa, Kan., has some grading on the Missouri, Kansas & Texas R. R., between Sedalia and Nevada, Mo., suitable for small team outfits to sublet.

J. W. McMurray and Roger Fabion of the McMurray Contracting Co., Kansas City, were with us the other day. Will probably report something new about them in next issue.

Wm. J. Danklef, of Mt. Olive, Ill., was awarded the contract for building new yards for the Donk Bros. Coal Co. on the St. Louis, Troy & Eastern R. R. at Edwardsville, Ill.

Contractors when in want of work or labor for their outfits write Koenig Labor Agency, 612 Walnut St., St. Louis, Mo.; 503 Delaware St., Kansas City, Mo., or 509 S. 13th St., Omaha, Neb.

W. R. Larsen Const. Co., Sioux Falls, S. D., have some nice county road work to let in South Dakota. Want to get in touch with one or two elevating grader outfits for several years' work.

John O'Leary, of the Cherryvale Const. Co., put in an appearance here the other day. The first time in seven or eight years. John says they have been busy paving streets in and around Cherryvale, Kan. Quit the railroad game some time ago.

The Good Roads Const. Co., 422 Bank of Commerce Bldg., St. Louis, Mo., were awarded contract for 48½ miles of road work near Blytheville, Ark. They are also low bidders on 40 miles of State road work south of Vandalia, Ill. R. E. Cotton is now with this firm.

Hickey Bros. have started work on the first half mile of subway that they are building for the Rapid Transit Co. in Cincinnati, O. Have opened an office on Ann and Plum Sts. there with Pat Hickey in charge. They still have about 2 years' work on the Scioto River at Columbus, O., constructing retaining walls, bridges, etc.

Costello Bros. Co. got in on a 3,000,000 yd. stripping job at Bauxite, Ark., for the American Aluminum Ore Co. They are going to place three shovels on this and have three years to complete job in. Mike Costello will be in charge. Costello Bros. are also building a 7 mile extension for the Southern R. R. into some coal mines and lumber mills near Oneida, Tenn. This work will be under Rich Costello with a team outfit.

The Darling Chemical Fertilizer Co., a Chicago corporation, has bought a tract of 20 acres on the Alton & Southern R. R. belt line, south of East St. Louis, near the Free Bridge, on which it will erect a plant. The property is near the plants of the Monsanto Chemical Works, the Indiahoma Refining Co. and the McCombs Producing and Refining Co. The company will ship phosphate rock by barge and rail from Tennessee and convert it into fertilizer.

A petition for a franchise to build two miles of track for an electric street railway in St. Louis county was filed in the County Court at Clayton, Mo., by John F. McDermott, a real estate operator, and others interested in the development of the Memorial Park Cemetery on Melrose Avenue and the Lucas and Hunt Road, St. Louis county. The proposed line which is intended to serve the cemetery, would extend one mile north and south, along the Jennings road, between the Natural Bridge Road and Melrose avenue, and one mile east and west along Melrose avenue, between Helen avenue and the Lucus and Hunt road. McDermott said the line would cost about $200,000 and when completed would provide a connection with the proposed Pine Lawn extension of the Natural Bridge line.

A. B. KOENIG.

Personals

A. S. Calkins has been appoined city engineer of Joliet, Ill.

Davies, Chism & Davies, constructing engineers, have opened an office in the Chamber of Commerce Bldg., Columbus, O.

Joseph A. Murray, Jr., has been appointed principal assistant engineer in the city bureau of engineering of Albany, N. Y.

The Blinn Engineering Co., Coshocton, O., has been organized by Ray S. Blinn, and will engage in a general municipal engineering practice.

Joseph Wespiser and A. D. Vanausdall have entered into a partnership and will engage in a contracting business, with offices at Oxford, O.

Amos Melberg, Benton county engineer at Belle Plaine, Ia., and E. S. Rife, county foreman of bridges, have resigned and will engage in contracting.

Gilbert P. Vute, 33 Park Ave., New Rochelle; Martin L. Ericksen, 209 30th St., Brooklyn, and John J. Hartman, have been appointed assistant engineers in bureau of buildings, Manhattan Borough, New York City.

W. J. Cooper and F. E. Hilton, both of Salt Lake City, Utah, and Harold Mann, of Halway, Wyo., have organized the General Industrial Corporation and will engage in engineering and contracting, with main office at Kemmerer, Wyo.

Obituaries

Charles R. De Burgh, a contractor of Portland, Ore., died March 6.

Charles H. Edwards, Sr., contractor and builder, of Doylestown, Pa., died March 15, aged 71.

F. A. Martin, assistant county engineer of Shawnee county, Kansas, died Jan. 29, at the Still Rock Spa Hospital, Waukesha, Wis., aged 32.

Industrial Notes

The Weller Manufacturing Co., Chicago, Ill., is now represented in the Southeastern States by H. Deverell, 1401 Lexington Bldg., Baltimore, Md. Mr. Deverell was formerly head of Deverell, Spencer & Co.

The Lidgerwood Manufacturing Co. will have an interesting exhibit at the National Marine Exposition to be held in the Grand Central Palace, New York, April 12th to 17th. They will exhibit two types of their standard reverse valve cargo winches. They have installed a compressed air outfit, and the winches will be operated, and an actual demonstration made both of the hoisting ability of these winches and the extreme simplicity of their control. The exhibit is located at Booth No. 43 and is in charge of Ed. J. Boynton.

Ray T. Middleton has resigned as general sales manager of the Standard Steel Castings Co. of Cleveland to become vice-president and director of sales and advertising for Kelly Metals Co. of Chicago, Detroit and Los Angeles. Mr. Middleton's headquarters will be Chicago, where The Kelly Metals Co. will, at an early date, establish its principal production plant. The company will continue its present plants in Detroit and Los Angeles and later establish a third branch, at a point to be selected in the east.

The first milestone of the Engineering Advertisers' Association of Chicago was passed on March 9th, at which time the following officers were elected for the ensuing year: President, A. H. Hopkins, Adv. Mgr. The C. F. Pease Co.; Vice-president, J. J. Arnsfield, Adv. Mgr. Fairbanks-Morse Co.; secretary, G. S. Hamilton, Adv. Mgr. American Steam Conveyor Corp.; treasurer, E. I. Pratt, Adv. Mgr. Kellogg Switchboard & Supply Co. The following directors were elected to serve two years: L. L. Gerstenberger, Asst. Gen. Mgr. Imperial Belting Co.; J. B. Patterson, Dist. Mgr. P. H. & F. M. Roots Co.; G. H. Eddy, Adv. Mgr. Green Engineering Co. The directors who have another year to serve are: P. A. Powers, Adv. Mgr. Benjamin Electric Mfg. Co.; H. W. Clarke, Adv. Mgr. Chicago Pneumatic Tool Co.; J. C. Kinsley, Secy. G. M. Davis Regulator Co. The retiring president, H. L. Delander, Adv. Mgr. Crane Co., was elected ex-officio member of the Board of Directors. The following standing committees were appointed: Publicity—H. L. Delander, Crane Co., chairman; K. J. Evans, Jos. T. Ryerson & Son; A. R. Maujer, Industrial Power. Membership—H. W. Clarke, Chicago Pneumatic Tool Co., chairman; R. E. Juergens, Crane Packing Co.; H. E. Haase, Cameron Can Mchy. Co. The present membership of the association is 100. Any man engaged in advertising or selling engineering products is eligible to membership.

Foreign Engineering Review Quarterly Issue

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Roads and Streets—1st Wednesday
(a) Roads (c) Street Cleaning
(b) Streets (d) Municipal Miscellanies
(e) Management and Office System

Waterworks and Hydraulics—2nd Wednesday
(a) Waterworks (c) Irrigation and Drainage
(b) Sewers and Sanitation (d) Power and Pumping
(e) Management and Office System

Railways and Excavation—3rd Wednesday
(a) Excavation (c) Quarries and Pits
(b) Management and Office System (d) Steam Railways, Construction and Maintenance
(e) Electric Railway Construction and Maintenance

Buildings and Structures—4th Wednesday
(a) Buildings (d) Miscellaneous Structures
(b) Bridges (e) Properties of Materials
(c) Harbor Structures (f) Management and Office System

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British Workers' Objections to Systems of Payment by Results

Editorial in Engineering, London, Dec. 12, 1919.

The attitude taken up within the last few months by certain of the great trade unions in this country, in rigidly opposing all systems of payment by results, and their demands, under threat of strikes, to revert back to plain time work, raises afresh the question as to the exact nature of the objections to such systems. During the war, remuneration in proportion to measured output was fostered by the authorities virtually controlling industry, and under the pressure of circumstances was continuously urged upon employers and employed. The response was a considerable extension in application and scope. In spite of the higher earnings always accruing from this innovation, the present demand in certain quarters is, now peace is declared, to revert to plain time work. Workers are often swayed by their union officials to take up a stronger collective attitude than their individual inclination may dictate. In dealing with the opposition to payment by results, it may be stated that, whilst individually the workers concerned can rarely even define their objections, much less discuss them, yet it is apparent that the feelings on this subject are deep rooted and, in consequence, merit attention.

The strongest objections generally spring from the more intelligent classes of labor. The results of improved education are being more generally felt and bring, as must all such progress, the disadvantages of ill-assimilated knowledge and the dangers of incomplete understanding of economic conditions. A very considerable number of skilled workers at the present time are opposed to systems of payment by results. It would almost seem that the amount of the opposition is in direct proportion to the skill of the trade.

In this country, further, where the trade union movement is in a much more highly developed state than in any other, these objections are not only strongly held, but, in consequence of this development, are capable of being expressed with an organized voice. In those countries where trades unionism is gaining ground a similar state is no doubt in process of formation. In countries where labor organization is undeveloped, piece-work is quite general. It is not unlikely that, in such cases, the same process will be gone through as has and is the case here. In Britain, with the lesser-skilled workers, and also in the great trades such as the cotton, boot-making and coal-mining industries, work is almost exclusively carried out on piecework, generally according to list prices mutually agreed upon between the employers and the employed.

Systems of payment by results mean increased production. Frequently and repeatedly it is stated that the object of the resistance on the part of the workers, and the tendency and the inducement to "ca'canny" or restrict output, is to cause a greater number of workers to be required and employed to undertake a given amount of work. Against this can be cited the economic truth that the cheaper the product the larger the market, and, consequently, the greater the demand for workers. That payment by results cheapens production is admitted by all. To leave the matter thus—and there is perhaps too great a tendency so to do—means a deadlock. In this vital matter of the remuneration of labor, reasonably harmonious relationship between Labor and Capital is agreed to be one of the first essentials of the present serious times, however difficult may be the attainment. Our industrial future otherwise will be clouded by grave uncertainties.

If a belief is so strongly held, as is this objection on the part of the men to payment by results, one of two points will be conceded—either that ignorance is so prevalent and truth gains ground so slowly that our industrial future might well be despaired of, or there is some truth in the workers' attitude, to be revealed perhaps by regarding their position, which on direct analysis seems so fallacious, from different angles in order, if possible, to discover the underlying causes.

The question of the unemployed is concerning many minds at the present time, and is truly a vital one. How is it affected by payment by results? The following example illustrates actual occurrences and the effect upon the point of view of the men directly concerned will be obvious. When payment by results is applied to a shop working on plain time rates, the output is speeded up and more work is accomplished. The shop and production records consequent upon working on such a system show that there are more men in the shop than there is work to justify. Employes, in consequence, are paid off. Two reasons may be noted—firstly, output is accelerated and, unless foresight has been exercised, men will be out of work until such time as the demand created by the reduced selling price rising from the improved condition of production sets in; secondly, records of work accomplished are kept probably for the first time. The net result, however, is the paying off of men, and an unemployed man will be little inclined to take a long view or to find consolation in a contemplation of the increased earnings of those remaining in employment. It is a fundamental consideration that, before payment by results is mentioned, the shop and the work should be thoroughly organized, careful records kept, and there must be full assurance that there is adequate work ahead to ensure employment to all the workers. Ample allowance requires to be made when computing future performance, to the augmented output certain to accrue from the extra incentive of higher wages towards greater effort. In such a way one of the strongest arguments against systems of payment by results will at least cease to be emphasized by actual happenings in such a direct and forcible way as has so often been the case.

The subject of unemployment generally is too large for treatment under the heading of this article, although the fear thereof is real. It need not be supposed, as is sometimes the case, that the more intelligent workers do not appreciate that full employment follows from increased production and a state of national prosperity. To a certain extent the extreme Socialistic section of the malcontents have their influence on the masses, and in part the resistance to the adoption of remuneration according to output is stimulated with a view to protest against the present distribution of the wealth accruing from increased production, which is held to be unfair to the manual worker and out of proportion to his efforts towards its creation. Largely this attitude is simply the outcome of ignorance, and at the present time (neglecting war conditions), in the engineering industries in particular, it is probable that the opposite is true, and that the manual workers are receiving more, if anything, than their due. That the distribution of the earnings of industry amongst the various trades is not in proportion to their skill is probably the case, but does not arise under this heading.

Collective systems of remuneration are not subject to the same opposition as individual systems. In some quarters even the collective system or collective contract under certain conditions of operations is actually urged upon the workers by certain Socialistic organizations, as giving to them more power than hitherto in assessing their own wages and determining the conditions of work. The difficulties of operation and the objections to such systems have been already dealt with in Engineering (see vol. cviii., page 85), under the title "Collective Systems of Payment by Results."

It is the individual systems that engender the most resistance. Trades unionism has been built upon the foundation of collective bargaining, and in this country today the principle is generally conceded. The individual system except when a mutually agreed upon price list operates, entails dealing with individuals or small groups of individuals. Competition and jealousy between individuals is a possible outcome, as, for instance, where there are two workers on the same type of work, one who makes it pay handsomely and the other who runs the job into debt, not having the adaptability, perhaps, to this particular class of work. Such cases advertised by unsuccessful workers may form centers of discontent. If the system is well administered, such incidents will be so handled as to minimize any bad feeling.

A number of skilled workers aver that the tendency to scamp work, in order to increase production and earnings is fostered by payment by results, and that the deterioration in quality of product more than counterbalances the gain from the speeding up. Such a tendency is undoubtedly present. It is, however, counteracted by improving the supervision and inspection departments, and this should be done, if necessary, before the system is inaugurated.

Competition is a strong stimulant, but there are limits beyond which it may be harmful. In industries this is recognized by the trading arrangements which are made with a view to restricting undue competition.

Furthermore, of the individual systems, the various bonus systems are much less popular than piece work. The workers do not understand why they should not be credited with the whole of the time saved, instead of with the 33 per cent, 50 per cent, 66 per cent, or as the case may be, according to the particular system in operation. They do not realize that it is of relatively little importance which of the various individual systems are adopted. The manner in which the system is administered is the all-important factor. If the estimates of prices or times are meagre, then little pecuniary gain will result whichever system be adopted, and conversely. Any questions having an influence upon wages require careful and experienced administration. Several pitfalls have been indicated. All considerations of payment by results inevitably come back to the setting of the basis time or the piece price. Upon this factor many of the difficulties center. Increased experience, improving administration, and above all, accurate rate setting on a scientific basis must be relied upon gradually to raise the question of payment by results in the workers' minds from the present shadow of suspicion engendering opposition, to a firmer footing of confidence tending towards maximum production and high earnings.

The Bias of Engineering Experts

Editorial in Indian Engineering, Calcutta, India, Dec. 13, 1919.

Mr. Morley Roberts once delivered himself of the aphorism, "Few men know their own business, for it cannot be understood without knowledge of things outside it." The comment is worth some thought, because at a time when the world is specializing more and more we find the common-sense of specialists so frequently impugned. The question concerns engineers, they are experts—at least it may be hoped that they are, and considering the enormous range of their subjects, there is no reason why they should not specialize, but in specializing it is essential that they should preserve their sanity. As human beings we are endowed with many faculties, and if we bring into concentrated employment any one faculty to the exclusion of all others, we are liable to become incapable of sound judgment on any subject, and possibly least of all on the subject which is peculiarly our own. There is an obvious advantage in possessing an intimate knowledge of some one branch of work instead of a smattering of many, but we lose that advantage if we fail to understand our own business from ignorance of things outside it.

In law it is not uncommon for scientific witnesses to be thoroughly discredited, or even ridiculed. In Ameer Ali's and Woodroffe's "Law of Evidence" it is stated, "The Evidence of Experts is to be received with caution, because they may often come with such a bias on their minds to support the cause in which they are embarked that their judgments become warped, and they themselves become, even when conscientiously disposed, incapable of expressing a correct opinion." These, coming from the learned authors of a standard work on evidence, are strong words, but there is nothing new or startling in them. Similar views have been expressed by judges in England on various occasions. Sress is laid on the bias of experts, the natural inclination to plead the cause for which they are employed at a remuneration, and it is possible that such a bias, due to a desire to render service in return for the payment received, may come into operation. But it is presumed that it would be involuntary and unconscious, for it is hardly to be supposed that scientific experts are more dishonest and less truthful than other witnesses, and it seems more likely that the so-called bias is the result of the ill-balanced judgment of the intense and narrow specialist. He is discredited by those who have no knowledge of the particular subject because he shows that he does not know his own business from want of understanding of things outside it.

The intensity of the specialist appears to lead to defective mental sight, a sort of intellectual myopia. It is related of Josiah Wedgewood of ceramic fame that he used to inspect the outturn of his factory hammer in hand, and relentlessly destroy every piece of china which he considered too flawed or blemished to be issued to the world bearing the Wedgewood mark. The habit was chronicled because it was held to be sufficiently curious and remarkable at the time, but it is believed that at all china factories of reputation examiners are now employed to inspect every piece before it is passed in order that the good name of the factory may not suffer. The examiners, whose sole duty it is to look critically for cracks or defects, are apt in time to become afflicted with what is known as "china-blindness," and when that is so, they have to be moved from office until a normal sense of vision is restored. China-blindness does not mean an inability to see defects, but an abnormal, hyperacute vision which magnifies deficiencies. It is a diseased vision, and suffering from it the examiners pass nothing. They are right in a way because nothing—the work of men's hands—is ever absolutely perfect; but they are nevertheless wrong because they fancy they detect what for the practical purposes of the world is not there. In short they become unreasonable, and they have to be removed, not by experts of superior qualifications, but by men of commonsense. Their judgment is discredited in the same way that judges discredit the evidence of unreasonable specialists in court. They are found not to know their own business because they have lost the perspective of it in relation to the things outside.

Every one knows that if there is a suspicion of organic disease, it is wise to consult an ordinary medical practitioner in the first instance, and the specialist only when the practitioner so advises. Otherwise, whatever the organ, the specialist in it is apt to find something very wrong. The specialist in any organ assumes that the patient must suffer in that organ, or why should he come to him? But it seems a little unfair to speak of bias, the desire to render service return for a fee. There is no question of bad faith, and we prefer to regard it as a form of blindness. The expert is liable to see his special business in a very vivid light, and ouside it there is nothing but darkness. It is against that form of defective vision we have to be on our guard. The all-round engineer with his varied work is in no danger, it is when we highly specialize that we need all the commonsense we can muster in order to use our special knowledge with effect. Our expert knowledge may enable us to play with sophisms with great dexterity, but that is a temptation we must resolutely resist. Our specialty must be corelated with every ramification of business outside it, and we must aim at a wide and comprehensive grasp of affairs, as the ability to picture all things in their proper relation to each other, if we are to avoid the reproach of not understanding our own business.

An Expert on Industry

Editorial in Engineering, London, Dec. 12, 1919.

It is a serious misfortune that engineers who play such a prominent part in the creation of wealth are far from successful in impressing on the public their views as to industrial and economical conditions. The proceedings of our technical societies are for the most part ignored by our daily journals and monthly reviews, while great deference is paid to the views of men far less competent on such matters. In the House of Lords on Tuesday last, for example, Viscount Haldane made the grotesque misstatement that "we had never really thought out the electricity question in this country, but left it to private enterprise." This inaccuracy will probably be repeated in hundreds of daily journals; whilst the true statement of the case, as given by Mr. J. C. Sparks in his presidential address to the Institution of Electrical Engineers in 1915, was, to put it mildly, exceedingly inadequately reported. No competent authority will deny that had the electricity question been left to private enterprise here, as Lord Haldane suggests was the case, we should have had splendid systems of electrical power distribution all over the country, and the need for the Electricity Supply Bill now under discussion would never have arisen, and the nation would have been richer by scores of millions per annum.

It is to be feared that the interesting and thoughtful address of Lord Weir to the Institution of Marine Engineers, delivered on Dec. 2 last, is little more likely to attract the attention of the daily press than did the pronouncement of Mr. Sparks four years ago. In this address Lord Weir brought the special experience of the engineer to bear upon a number of important industrial questions now pending. The engineer and the "Fabian" approach such questions as the nationalization of an industry from opposite standpoints. The Fabian asks—What is plausible, not what does experience show to have happened in the past.

A characteristic instance of this unscientific attitude of mind was quoted by Lord Weir from Mr. Sidney Webb's evidence given before the Coal Commission, evidence, which it may be added, would probably never have been tendered had not the witness been well assured that he was safe from effective cross-examination. The quotation is:

"If the miners are assured that improved processes would deprive no man of regular employment at the standard rate it is difficult not to believe that a Government Coal Department could in a few years revolutionize the processes of the backward half of the collieries." Lord Weir pointed out that Mr. Sidney Webb would thus control the rate and extent of the application of new processes by the state of employment. If, for example, a new system of transmitting energy particularly applicable to coal cutting were devised, making the present output possible with half the number of men, then, as Lord Weir points out on Mr. Webb's thesis, the new process should be banned. There is, however, another objection perhaps still more fundamental to the doctrine criticised. It will be seen that Mr. Webb was extremely careful in his phraseology. No doubt it is possible to conceive that a Government department could revolutionize the industry by the adoption of improved processes. But the scientific engineer is not concerned with what is conceivable but with what is probable. Is there, in fact, any reason for believing, in view of the past record of Government departments, that the benefits in question would be actually realized? An eminent American engineer has stated that until the telegraphs were taken over by the Crown, three-fourths of the improvements effected in telegraphy originated in this country. Subsequently the improvements we adopted were almost wholly imported, as the Government control had the effect of closing almost completely one field for creative thought.

It is true that the German State railways were reasonably well managed before the war; but, in the first place, it may be noted that the control was autocratic, and, secondly, that the standard of efficiency attained was not due to creative thought, but to studying and applying the results of the pioneer work carried out elsewhere. This was particularly the case with respect to safety appliances. Indeed, a study of the results of the working of co-operative societies leads to a similar conclusion. So far they have founded no new industry nor made any notable addition to our means of controlling and utilizing the great forces of nature. The whole of the evidence available strongly supports the view that progress in the arts would be slowed to a remarkable degree were private enterprise eliminated.

Another contention of the Fabian school is criticised by Lord Weir. The claim is made that the miner or other worker will, as an individual, work better and at a higher rate of intensity and lose less time if he is in public employment rather than in private service. Lord Weir says that in actual experience there is no substantial difference in the spirit with which a workman works whether he be employed by the Scottish Co-operative Society, the Glasgow Corporation, or by the Fairfield Shipbuilding Co. Indeed, it will be remembered that the low output of certain bricklayers in the direct employment of the L.C.C. gave rise to a scandal some years ago, and the state of affairs disclosed by the report on the Leeds municipal strike in 1913 showed great slackness amongst the employes of that city Facts, it has been said, are stubborn things, but the stubbornness with which the would-be social reformer ignores them is still more astonishing.

A further claim which Lord Weir demolishes is that Government control would abolish overlapping. Speaking in the fullness of his experience, Lord Weir states that there are many water-tight departments in Government offices, and overlapping is by no means rare. It may be added, morevoer, that overlapping is not necessarily an evil. For instance, it may happen that the same problem is being considered by independent minds, each with power and authority to conduct its own inquiries and make its own experiments. What one man may deem to be insignificant, another, conducting the same research, may prove to be of first-class importance. A striking instance of this was afforded by the discovery of

Argon, which was the result of a man of genius repeating experiments of a type made many times previously by numbers of skilled analysts. The slight discrepancies they ignored, Lord Rayleigh deemed worthy of further investigation, and thus discovered the first of a whole series of new elements.

Recognizing that the prosperity of the country depends upon its productivity, Lord Weir is seriously exercised by the re-imposition of the Union regulations, restricting freedom of employment, which were partially relaxed during hostilities. We believe that a somewhat similar condition of affairs arose in connection with Cromwell's army, whose members, when they sought, on discharge, to engage in various industries, were met with the prohibitions of the Trade Guilds. In that case, we believe, that the soldiers won in the struggle, and if it be true that the unions are now restricting the engagement of men who have lost their opportunity for learning a trade because they were defending the workers at home, it is to be hoped that history will repeat itself. As matters stand, Lord Weir states that the war demands for the products of the machine shop were in excess of those of the foundry, and that now more normal conditions have been restored an enormous increase is needed in the foundry capacity of the country.

The number of ironfounders, he states, is from 5,000 to 7,000 below the number required to keep our machine shops going, and under present restriction it is not easy to see where the men are coming from. Possibly improvements in foundry practice may enable higher outputs to be attained per head employed, but innovations of this kind are very difficult to introduce.

In another part of his address Lord Weir commented on the very small space devoted to these important industrial problems by the daily press which can find columns wholesale for the reporting and discovery of an unimportant inquiry in the House of Lords, but can hardly spare a paragraph to the setting forth of the pertinent facts connected with the present strike of the ironmolders. This is the more to be regretted, as public opinion has an enormous effect in bringing such matters to a settlement. Neither workmen nor employers will nowadays hold out against the pressure of well informed public opinion, and it is accordingly of first importance to the country that the daily press should supply complete and accurate data on which this opinion may be based.

English Comments on Am. Soc. C. E. Development Plan

Editorial in Engineering, London, Feb. 13, 1920.

At a time when some of our technical societies are branching out in new and untried directions, it may be of interest to notice what is happening in this way in the United States. In doing so we must remember the difference in the physical characteristics of the countries served. The greater distances of the American Continent make it less easy to work in one chief center. In fact, the conditions there are more nearly represented by the British Empire than by the United Kingdom.

If we may rely on the trend of opinion expressed at local or section meetings of the American Society of Civil Engineers, which has a membership of about 9,000, there is a general consensus in support of the proposals brought forward by a development committee of the society which sat last year with the object of defining lines of possible future policy. The report which this committee has submitted deals not only with the internal affairs of the society, but also with its external relations with other kindred bodies, and with matters of national importance.

Broadly speaking, if we deal with the internal affairs first the report favors decentralized activities. That is to say, it proposes a policy of building up strong local sections, instead as hitherto concentrating in New York. The central organization would be retained in a modified form, but it is proposed to abolish the fortnightly meetings. In lieu the local sections are to hold not less than four meetings per annum, while the half-yearly meetings of the parent body might, it is suggested, be supplemented by two others, making four large meetings held in succession in various parts of the country, in co-operation with the local sections. The idea evidently is that a larger number of members would benefit from these two kinds of meetings than can possibly do so from the meetings held in New York, which can only be conveniently attended by a few. Further, of course, more members would make an effort to attend a meeting of some days' duration, not too far away, when a long journey for a single evening would be out of the question. There would, in addition, be an annual meeting and an annual convention, at both of which technical matters would form a prominent feature.

It is proposed that every member be assigned to a local section, and shall affiliate with members of allied professions for co-operation in public matters. The local sections would combine in geographical districts and each section would have its representative on a district board. Representatives of the local sections would also meet at the annual conference and discuss matters affecting the welfare of the whole body, and would elect the chief officers, the delegates having voting powers in proportion to the strength of their sections.

There is evidently a feeling that some of the conventions organized by these large American bodies are verging on the frivolous, for it is suggested that sociability should not be allowed to interfere with the more important duties of the society; and again we find that no excursions should be scheduled for the first day. Apart from the usual business at the annual meeting, and the presentation of reports of technical and other committees, etc., it is proposed that there should be a carefully-planned program of addresses and discussions on technical and social problems of national importance. It is felt that the voluntary haphazard system of papers is unsatisfactory and that definite and logical programs should be arranged. Descriptive papers should be brief, and more attention paid to the lessons of successes and failures, while financial, administrative and other factors controlling the engineering problems dealt with, should be given more attention. These suggestions might be noted with advantage by prospective authors over here.

The portion of the report dealing with external relations was drawn up in conjunction with committees appointed by the American Society of Mechanical Engineers, the American Institute of Electrical Engineers and the American Institute of Mining and Metallurgical Engineers. This joint report recommends a national engineering organization, embodying a national council and local affiliations, with possibly State councils as a kind of go-between. The formation of these would naturally strengthen local action in public matters. The object of this organization is to advance the influence of engineers in national affairs, to render the nation enhanced service by unity of action, and to provide machinery for prompt and united action on matters affecting the profession, such as the licensing of engineers, conservation of national resources, public works, education, industrial relations, and so on. These, of course, are laudable objects. The difficulty will be experienced when actual work is attempted. It is a great deal easier to make such suggestions than to produce definite recommendations of material value. However, there are plenty of directions in which authoritative guidance or ruling would be advantageous. The actual form of the proposed national organization is to some extent vague, but the local or affiliated bodies would be represented on it. The National Council would hold meetings once a year or so, and there would be an executive board of not more than 30, with salaried officials and headquarters.

The State is, so to speak, the national unit of organization, and the plans proposed in this way fall in with the national arrangement, in which the States legislate for themselves, while the Federal Government endeavors to get them to work more or less in harmony for the good of the whole country. The local affiliations are intended to be strong enough to make their influence felt in matters within the individual States, while the National Council should develop into an authority of sufficient weight to make its influence felt in Federal questions. To make the local bodies strong the co-operation of the four leading societies is advocated, and also affiliation with institutions of kindred and allied professions. The co-operation of the four founder-bodies is to extend to all professional matters, including standardization, employment, etc. Joint meeting should be held, while industrial relations and educational movements, etc., should also form the subject for co-operation with affiliated bodies. A national code of ethics for the profession is suggested by the committee, which, however, consists mainly of an elaboration of one of the clauses adopted, which reads as follows: "The right relation of the engineer to his profession is succinctly embodied in the golden rule 'All things whatsoever ye would that men should do to you, do ye even so to them.'" With the official endorsement of such a principle, which is as sound now as when it was enunciated, the popular view based on the parody "Do the other man as you think he would do you, but do him first," must needs be revised. We need hardly say that the latter has hardly been taken seriously as the real motive of responsible men among our friends across the Atlantic.

New Sources of Power

Editorial in Water and Water Engineering, London, Jan. 20, 1920.

In the Trueman Wood lecture [abstracted in this issue of Engineering and Contracting], delivered by Sir Oliver Lodge at the Royal Society of Arts, the subject selected was "Sources of Power, Known and Unknown." The fascination of this theme arises partly from the enormous waste and extravagance of even the most perfectly-designed heat engine, and partly from the fact that there undoubtedly exist stores of energy the utilization of which is not beyond the possibility of ultimate discovery. Science is moving rapidly in these days, and we may be nearer than we imagine to a realization of a complete revolution in power development. Sir Oliver Lodge discussed, in the first place, the question of atomic energy, which he considers to be rather inaccessible, but not hopeless.

A familiar illustration is to be found in radio-activity, a form of energy which differs only in degree from that which all atoms possess, in greater or less degree in proportion to their weight. Atoms may be likened to cordite or gunpowder, and are liable to develop energy under a suitable stimulus. Radium and uranium differ in requiring no apparent external stimulus. But in other cases an appropriate stimulus, such, for example, as X-rays, may to some extent disturb atomic equilibrium and develop energy. The amount of energy that can thus be developed is weight for weight about a million times that of a bullet fired from a gun. The possible energy in about 30 grains of matter may thus be measured by 10^{19} ergs., a foot-ton being equal to 3×10^{10} ergs. Thus, even a few grammes of matter contains enough atomic energy to raise 100,000 tons through 3,000 ft.

Possibly this energy is already being utilized in various ways, such as, for example, as suggested by Sir Oliver Lodge, in color vision, and in certain obscure physiological processes; but whether the day will come when science will discover a method of harnessing atomic energy is, of course, highly problematical. We have learned of late not to be too skeptical with regard to future advances in physical knowledge.

The known facts of today would have been more incredible a few years ago than any of the possibilities suggested by Sir Oliver Lodge. Let us take only one instance: the direct utilization of wireless electricity. The length of the waves, electro magnetic in character, employed in wireless telegraphy, may be of the order of some hundreds or thousands of meters, with a frequency of millions per second. These are developed as alternating currents, too rapid for any known mechanical device to respond to them. But a method has been devised by which these currents can be rectified, viz., converted into uni-directional pulsations, behaving like continuous currents and capable of operating telephones and other electro-magnetic devices. This indicates that we have the means of converting radiant energy into mechanical energy with a very high degree of efficiency, perhaps as high as 50 per cent or more, and this single fact seems to open up possibilities which earlier generations would have regarded as the wildest fictions of the imagination.

Quite recently, Mr. A. A. Campbell-Swinton, writing in Nature, has suggested that just as we have learned to convert wireless waves into continuous currents, it may eventually be possible to treat in a similar way the radiant energy of the sun. Heat engines worked by solar energy are, of course, already available, but owing to the limitations imposed by the second law of thermo-dynamics, a heat engine of this type has a very low efficiency, utilizing perhaps not more than 4 per cent of the theoretical amount of available energy.

The total solar energy intercepted by the earth is stated by Mr. Campbell-Swinton to be about 4,000,000 hp. per square mile of the earth's surface in moderately high latitudes. Even in the damp British climate, this would represent about 1,000 hp. per acre throughout the hours of daylight. The conversion of this energy into mechanical work by methods other than heat engines is quite conceivable if we regard solar radiation as electro-magnetic waves in the ether. We are, of course, aware that Prof. Einstein has recently sought to deprive us of our ether, but probably this would make but little, if any, practical difference to Mr. Campbell-Swinton's argument, because he regards the problem as being somewhat analagous to that of the wireless waves referred to above, that is, assuming the truth of the electro-magnetic theory of light. The chief difference lies in the fact that the solar waves, viz., sunlight, are measured in fractions of a millimeter in length with a frequency of billions per second.

What is wanted, therefore, is to discover some kind of rectifier, similar to the thermionic or crystal rectifiers employed in wireless telegraphy, capable of dealing with electro-magnetic light waves in the manner already successfully applied to wireless waves. If this could be done we should possess an inexhaustible store of readily convertible energy, able to be used with an efficiency many times greater than that of any known heat engine of today.

Is it necessarily a very great step to the realization of such possibilities? What a revolution it would entail in the industrial life of the world! The dethronement of King Coal would be but a small part of the consequences of such a discovery. We do not, of course, anticipate any such stupendous event immediately; but the obvious moral may nevertheless be drawn. The more expensive coal becomes as a source of power, the greater will be the stimulus to find a substitute. It would not, of course, render coal mining any the less necessary, but coal would then be got rather for the sake of its innumerable by-products, than for the heat units that can be obtained from it.

The Woman Engineer

Editorial in The Engineer, London, Jan. 9, 1920.

The position of women in engineering and other professions and trades is one of those matters that will settle itself. If they are better than men, they will get work, and if they are not they won't, and that, as our American friends would say, is "all there is to it." That is the final position which will be reached when equilibrium has been attained. Speaking as mere males, it does not alarm us a great deal. Nature has not fitted women for engineering, and though here and there one may break away from the normal, just as we may find now and then a great woman novelist or a tolerable woman artist, so a few times in a century women may reach eminence in engineering. When we say engineering, we mean engineering, and we do not mean the mere mechanical handicraft which has been so facilitated by a succession of inventions that, except in a few occupations—rapidly disappearing—where muscular strength or physical endurance is required, anyone can become an expert in a few weeks. It is astonishing that women should desire to engage in such work. But the sex was always, and will always be, incomprehensible. We are sorry to see from the first number of a little quartely published by the Women's Engineering Society, and called the Woman Engineer, that mechanical craftsmanship and engineering are confused, though we admit that the bad example was set by the male sex. But it is unfortunate that just at a time when engineers are endeavoring to effect some distinction between the mechanic and the scientifically trained engineer anything should be done to support or perpetuate the misuse of the word "engineer." If women desire to remain in the craft of engineering they must be content to call themselves women-mechanics, women-machinists, women-fitters, and so on. With the example of the ill that has resulted from the confusion amongst men engineers, they will be ill-advised if they do not take earliest opportunity of making a clear distinction between those who are able to earn a decent income by a training extending over a few weeks or months and those others, on a higher plane, who, after years of study, and considerable expenditure of their fathers' money, manage with difficulty to make both ends meet, and only in exceptional cases have the pleasure of seeing them lap over.

Government Control and Management of Industries

Editorial in The Engineer, Dec. 19, 1919.

To commend to the attention of our readers those parts of the presidential address to the Institute of Marine Engineers which we printed last week would appear to be wellnigh an act of supererogation, for whoever read but the first few lines would scarcely turn his eyes from the page till he had read the last words. Lord Weir has always had at least one high quality as a public speaker—a directness and precision which leaves no doubt in the mind of his audience as to his meaning. He takes a clear view of his subjects, sees them from a single aspect and does not permit his reason to be bandied from doubt to doubt till it is lost in a mass of reservations. With him there is no "drowsy equilibration of undetermined counsel." He drives towards his goal with a resolution and singleness of purpose which is not to be arrested or even hindered by the obstacles, pitfalls and snares which set lesser men on such a tortuous path that it is a wonder if ever they reach their journey's end. A close observer of the causes of Britain's greatness, he is a confirmed individualist and will have no truck or dealing with nationalization. The framework of his objection to the Government control and management of industries is set out in this address under five headings. They are not unfamiliar, but they gain twice their old force coming from the lips of one who for many months was thrown into daily and hourly contact with the governmental mind. Lord Weir has been an industrialist and a business man for as long as he can remember. That he knows how business should be conducted is evident from the success of the firm of which he is head. He was able to contrast the conduct of affairs by the Government with its conduct by the men of affairs whom he met in his daily work, and that the contrast was unfavorable is evident from the opinion he formed of the capability of the Government—of any Government—to carry on great industries. But he does not stand alone in this respect. It is only the theorists who honestly believe that the efficiency of industries would be increased by nationalization, and we doubt if a careful sieving of the country would reveal half a dozen men experienced in the employment of labor and the management of industry who could as whole-heartedly express approval of Government control as Lord Weir expresses objection to it. He does not assert that the conduct of private enterprise is perfect, but what he does say, and in that we are perfectly at one with him, is that "if the spirit that assails private ownership were directed to the bettering of the existing system instead of to its overthrow, it is practically certain that the grievances and hardships complained of could be removed without recourse to gigantic experiments, the results and subsidiary effects of which no man is capable of predicting."

Engineers in Business

Editorial in The Engineer, London Jan. 9, 1920.

In an address which he delivered early in December to the Midland Section of the Junior Institution of Engineers, Professor F. W. Burstall alluded, with a touch of regret, to the fact that the engineer, despite his technical skill, is deemed "incapable of the management of a large organization, and that when it comes to matters of public policy and the government of large technical industries, such as mines and railways, the person put in supreme command is either a business man or a lawyer." Professor Burstall is certainly not unaware that there are several notable exceptions to the practice of which he spoke, but in a general way he was undoubtedly right in his facts. Whether or not it is a matter for regret that engineers are not entrusted with the management of great organizations is quite another question. Business is one thing and engineering another, and on the whole we are disposed to think that the less the engineer has to do with business the better engineer he will be. There is, we suggest, not the least reason to suppose that education in science and technology fits a man for the management of affairs, and it seems not much more reasonable to ask that engineers should be appointed heads and directors of great organizations than it would be to give positions of technical responsibility to lawyers and business men. Professor Burstall recognizes that engineering is based on science, but he does not, perhaps, see quite so clearly that business has also its science, and demands just as close a specialized education as that given to engineers. The classical example of Boulton and Watt remains, as it will always remain, the ideal combination; on the one hand a business man with a keen sympathy for science, and on the other hand an engineer with a keen sympathy for business. It does, of course, not infrequently happen that a man who starts life as an engineer finds himself drawn into the meshes of business, and gives up a great deal of his technical work, but whenever that happens the world is the loser, for it is probable that the technical ability which originally displayed itself would have developed further had it not been diverted and obstructed by non-technical affairs. We all know that for years past the technical managers of great engineering works have found their time increasingly engaged by labor problems—a form of business of a very serious kind. Can anyone doubt that such is an undesirable state of affairs? Far better would it be to appoint a business man, or even a lawyer, to attend to all these matters than to keep the engineer away from the study of the subjects in his proper province.

Motor Vehicle Taxation for Road Upkeep

Editorial in The Engineer, London, Feb. 6, 1920.

The government proposal to increase the taxes on motor vehicles will not have come as a surprise to those who were present at the dinner given by the Society of Motor Manufacturers and Traders at the opening of the Motor Car Show at Olympia last November. At that function Sir Eric Geddes, who was the principal speaker, indicated in no uncertain terms that the users of motor vehicles would have to contribute considerably more than in the past for the upkeep of the roads. The figures he quoted for the then cost of road construction were a very convincing argument for increased revenue from those who made use of the common roads. Hitherto, as our readers are aware, this revenue has been obtained from two sources: a graduated tax on the private vehicles and a tax of sixpence per gallon on petrol. It is now proposed to do away with the latter and place a much higher tax on the vehicle. One pound per horse-power is suggested, which would mean in the case of most cars a tax of between three and four times that at present in vogue. If all cars were of about equal value and weight some such formula would be generally fair, if perhaps excessive; but there are different classes of cars. There is the humble Ford and the lordly Rolls-Royce, the one costing as many hundreds as the other costs thousands; the one weighing perhaps 12 cwt. or 13 cwt. and the other over two tons. On the suggested horse-power assessment alone the tax on the Ford would be out of all reason compared with that on the Rolls-Royce, while if wear and tear of the roads is considered the difference in the weights should enable the lighter machine to escape with a much smaller relative impost. We should suggest, therefore, that the taxation of private cars and commercial vehicles alike should be based on some formula which takes into consideration both the horse-power of the engine and the weight of the vehicle, as by that means the taxation imposed would bear some relationship to the wear and tear inflicted on the road surfaces.

Pile Driver Operated by Motor Truck.—During the military operations on the Salonika front it was necessary to construct a bridge across the Selimb River. The work required the driving of 48 piles about 40 ft. long and 12 in. square to a depth of 24 ft. in gravel, clay, and quicksand. A pile driver with 30 ft. leads and a 1,200-lb. hammer was employed and a 4-ton motor truck used to raise the weight. The truck was set up on the bank, the left-hand rear wheel was jerked up and blocked 10 in. from the ground, and the other three wheels were snubbed and staked to the ground. The lead rope was given a turn on the brake drum inside the wheel, one man operating the loose end. The distribution of labor was as follows: One motor driver, one signalman, one on the lead rope, three on the pile driver, and two sharpening and putting on pile rings. Work was continuous in three 8-hour shifts, and bridge was completed for traffic in 12 days.—The Engineer.

A New Source of Power: Atomic Energy

By SIR OLIVER LODGE.

Abstract of lecture delivered Dec. 10 before Royal Society of Arts.

Is there any concealed store of energy recently discovered and not yet utilized? There is indeed. There are two—one certain, the other rather hypothetical; the energy of the Atom and the energy of the Ether. I purpose to say nothing about etheric energy. If it exists, as I think it does, it is enormous, exceeding the bounds of imagination; but at present it is utterly beyond our reach. Atomic energy is rather inaccessible, too, but not hopelessly so. It is far less in amount than etherial energy, but it is immense compared with any form of chemical or molecular energy, such as that derived from combustion or explosives.

By atomic energy I mean the constitutional energy of an atom—the energy which makes it what it is. If this energy is given up in any considerable degree the substance ceases to be what it was, and becomes a substance lower down in the scale. Utilization of atomic energy would involve the stepping down, the degradation, of matter. The term is purely technical—it has been already applied to energy without moral stigma. All it means is that heavy atoms may become lighter atoms, and in so doing must give off a definite proportion of their great store of energy.

Radio-Activity.—This spontaneously happens in the phenomenon known as radio-activity. If it had not spontaneously happened, we should have known nothing about the energy concealed in an atom. The explosive or radio-active atom has given the secret away. All atoms possess energy, but some cannot hold it all. These are the radio-active elements, and they periodically fire off projectiles with more than volcanic violence. A radium atom firing off a particle, which turns out to be a positively charged atom of helium, is like a 2-ton gun firing a 100-lb. shot. That is about the actual proportion between the projectile and the rest of the atom, which naturally recoils each time it fires. The recoil has been observed. Before it has exhausted its ammunition it fires off five such projectiles, and then settles down into a quieter existence as lead—or, if not exactly lead, something chemically indistinguishable from lead. A uranium atom had already fired off four projectiles in order to become radium. Radium is a temporary half-way house between uranium and lead; it is active, but not so fiercely active as some of the intermediate substances which last so short a time that they barely have names. They destroy themselves by their own activity, and consequently are very scarce—like a population with a high death rate. Radium is of moderate activity; its lifetime is of the order a thousand years, whereas the lifetime of some of the intermediate substances may be measured in weeks or even minutes. Yet they are real elements, with a place in the series and they have definite spectra and chemical properties.

Do not suppose that the well known radium is an exceptional substance. It would seem that all substances of very high atomic weight are liable to behave in this way—it is only a question of degree. And it is not by any means their whole energy that they thus exhibit, it is the energy they expend and get rid of—their waste energy—which we percieve. And when we speak of their explosion, it is to be noted that the explosion is not a shattering or bursting of the gun, it is merely the firing of a shot; except that in the atomic case the shot was part of the gun. The energy retained is far more than the energy expended. And when its active transformations have ceased and left it in a stable state, like lead or gold, or silver or copper, or iron or any common element, we are not to suppose that because it is quiescent therefore it has no store of internal energy. Appearances are deceptive. Anyone looking at cordite might think it harmless enough, and so it is till a suitable stimulus is applied. It does not, or at least, it is not wanted to, go off spontaneously. Gunpowder and any other explosive exhibits no trace of its secret to mere inspection; nor do the atoms of ordinary matter show that they are fearfully energetic, but the energy is there.

We may go on to ask: What corresponds to the gun-powder when I speak of a gun firing a shot? What propels the projectile? It is a very proper question, but at present it can only be partially answered.

The Alpha and Beta Rays.—There are two kinds of projectiles fired off by a substance—the heavy shot or α ray, which is known to be a helium atom, and the lighter shot or β ray, which is the fundamental unit of electricity, the negatively charged unit particle—an electron. Several electrons may be expelled, and they will not make much difference to the weight of substance left behind, but they will have left it positively charged; and in that case it is liable to fling away one of its massive positively charged particles too. One event follows the other, and whether the electron always escapes first is uncertain. Whichever event precedes, in different cases, the other is likely to follow.

Many circumstances can stimulate the escape of an electron; not, indeed, of the deeper-seated constitutional electrons, but of the outlying superficial charges which are responsible for chemical affinity. Mere friction removes some of them, and leaves the substance positively charged. The removed electrons will have gone to the rubbing substance, and will have charged it negatively. Splashing of water, chemical action in innumerable forms, effects the transfer of electrons, and consequent charging of bodies. Ultra-violet light falling upon clear metal, and indeed upon a large variety of substances, causes electrons to be expelled until the surface is positively charged enough to hold them back. The discharge will go on continuously if more are supplied from a battery. The jostling of the molecules by heat will often cause electrons to escape, but not usually until a temperature of red or white heat is reached. Singularly enough, a comparatively low temperature will emit a few positive particles for a time, as it were, but this emanation soon ceases, the material gets tired as it were, and has to be reborn or renewed somehow, if the process is to be continued. Not so with the negative emission from hot bodies. This will go on as long as fresh particles are supplied.

Stimulation of Escape of Stray Electrons.—In many ways, therefore, we can stimulate the escape of stray electrons, and it appears that by the aid of X-rays or of projectiles from other atoms, we are beginning to learn how to disturb effectually, and even to eject, the deep-seated constitutional variety; though usually others immediately take the place of the ejected one, with consequent radiation of definite type. If a pair of β particles were permanently extruded an α ray would probably follow in order to restore the neutrality of the atom, and the atom would have gone a step down in the scale. This happens spontaneously, but the result of experience is that we cannot bring about the catastrophe by ordinary means. We cannot alter the spontaneous rate by anything we as yet know how to do. Heating and cooling—alterations of molecular movement—seem impotent to get down to the inner mechanism. Still, we are certain that that inner mechanism is a most energetic system, and just as the internal charges are equally positive and negative, so I believe atomic energy is both static and kinetic—though perhaps not equally so.

The modern view of an atom is a central positive nucleus like a sun, and a revolving system of negative electrons like planets. The electric planetoids, so near this "sun" and subject to its powerful electrical attraction, must be revolving with prodigious speed with a frequency of orbital revolution exceeding in most instances even the frequency of light—a frequency only attained in general by the ultra rapid X-rays. Accordingly these little bodies have plenty of kinetic energy, and when they escape as β rays they do so with something like the velocity of light.

The frequencies possible in a hydrogen atom turn out, in Bohr's theory, to be of the order 10^{16}, being either 10^{16}, itself or else ⅛ of 10^{16}, or 1/27 of 10^{16}, the denominators being the natural cubes. For heavier kinds of atoms, this frequency must be multiplied by the square of the number allotted to the element in Mendelejeff's series. The diameters of the orbits will be of the order 10^{-8} cm. divided by the atomic number and multiplied by the successive square numbers, 1, 4, 9, etc.

The velocities will be of the order 10^{8} cm. per second multiplied by the atomic number and divided by the natural numbers, 1, 2, 3, etc.

So for the heavy atoms, whose atomic number is approaching a century, the inner electron speeds are getting near to the velocity of light, and hence probably their instability.

The positively charged nucleus is in different case. Its energy is more likely to be static, i. e., potential, like things held or caught together, as a detent may hold a strong spring. Let these be liberated, and they fly with great violence, presumably under the electrical repulsion; the potential gradient is at first enormous, so that each atom where it strikes a zinc sulphide target makes a luminous splash. Taking the size of the nucleus as comparable to 10^{-12} cm., the acceleration of an α particle is Ne^2/Kmr^2, m being the mass of a helium atom, and this equals $3 \times 10^{28} N^2$ centimeters per second at the start, and must be reduced to near zero, at the confines of the atom. (N is the atomic number.)

The projection of an ∝ particle is therefore literally an explosion, and the force can very quickly get up an enormous speed.

Amount of Energy Available in Atoms.—The speed with which an ∝ particle is ejected is about one-fifteenth that of light—sufficient to carry it to New York, if there were no obstruction, in a quarter of a second. Its energy is, therefore, weight for weight, a million times that of a bullet. Only because an atom is so small does it fail to do any damage.

But the number of projectiles from a millegramme of radium is about 30,000,000 a second; hence, in the aggregate, they do generate a very perceptible amount of heat. We may not know the exact cause of their retention or propulsion, but no one can deny that the energy is there. The main difficulty is to understand how they are retained and packed together into the minute nucleus.

As to the atom's negative electron energy, that is probably kinetic, they probably escape with the velocity with which they were revolving in their orbits before perturbation. This is rendered plausible by the fact that the emission depends on synchronism between the periods of the particles and the X-ray disturbance which ejects them. Their energy of ejection is found to depend on the frequency of the radiation which stimulates it; a fact which at once suggests a storing of received synchronous vibrations, till a quantum of energy sufficient for ejection has been accumulated. Moreover, spectrum analysis of the derived or secondary X-rays, emitted by a substance exposed to radio-active bombardment, is also a test of the frequency of orbital revolution.

Particles can be ejected from one of several orbits—called respectively K or L or M, the K orbit being the nearest to the nucleus and therefore of highest frequency. Electrons are ejected at speeds still greater than ∝ particles, and occasionally approach to within a few per cent of the speed of light.

If we calculate the amount of energy thus quietly existing in the atoms of any visible piece of matter, we shall find it enormous. If each atom is the seat of these high velocities, and equivalent high explosive forces, the aggregate of energy in a few trillion atoms is very great; and it takes fully a trillion atoms to make a perceptible speck of matter.

To illustrate the energy possible in any reasonably small quantity of substance, it is sufficient to reckon the energy in a couple of grammes, or, say, 30 grains, of matter moving at one-tenth the speed of light. It need not be moving in the sense of locomotion; internal motion of its parts does just as well; and static energy can be equally well included, since its liberation will produce these high velocities. The energy is 10^{19} cgs. units or ergs. Now a foot-ton is 3×10^{10} ergs. Hence the energy of a few grammes of matter is 300,000,000 foot-tons, enough to raise 100,000 tons 3,000 ft. If all its parts were moving with the speed of light, the energy would be a hundred times greater, but it is doubtful whether bodies can move at quite the speed of light. For, just as a bullet cannot move quicker than a thermally modified velocity of sound, so a body is unlikely to move through the ether quicker than the ether disturbance can get out of the way.

Practical Utilization of Atomic Energy.—No doubt a large store of energy is there; the practical question is, can we get at it and utilize it? We may even ask: Is any of it being utilized already? I do not think the answer is wholly in the negative; for that the activity of radium, thorium, and other radio-active substances, is employed therapeutically is well known. That was the beginning of practical application of the energy given off.

Atomic energy may unconsciously be being utilized in other ways, too. I have lately put forward an incipient radio-active theory of vision: I surmise that in the retina there must be a substance which can be stimulated into activity by the impact of ether waves of luminous frequency, that the substance then ejects a few of its outlying electrons, and that these stimulate the nerve-endings in their immediate neighborhood. The way in which air vibrations stimulate the auditory nerve has been fairly made out. It is a question of mechanism; but the way an etherial vibration stimulates the optic nerve has not been made out; it is not a mechanical, but an electrical question. Radiation of light frequency is known to be received and stored until it is able to eject a negative particle with whose orbital frequency it happens to agree. And certainly such a particle when ejected could be depended on to stimulate a suitable nerve-ending.

It is on those lines that I would explain the extraordinary sensitiveness of the eye. For the accumulation of a few million impulses would take no appreciable time, and it is difficult to suppose that in any other way than by synchronization with equally rapid motion, could matter be perturbed by the extraordinarily rapid vibrations of ether—hundreds of millions of millions per second. Nothing larger than the ultimate elements of the atom could be expected to follow such rapidity. Molecules of matter would be almost too massive and gross to be readily moved as a whole; and, besides, their movement as a whole would only result in heat.

The same sort of idea could apply to the stimulus of a sensitive photographic plate, only here the chemical atoms are attuned, as a rule, to still higher rates of vibration, and are susceptible beyond the ultra violet, into the region of χ and γ rays.

The facts of color vision suggest that the visual substance (visual purple, of whatever it is) is specially sensitive to three particular frequencies, one in the red, one in the green, and one in the violet; but there must be plentiful overlapping, so that intermediate wave-lengths may produce their full effect.

The whole idea at present is in the nascent stage; only it is instructive to think that possibly atomic energy may have been utilized in the eyes of animals all the time. It is conceivable that it may have been utilized for the light emission of glow-worms, though that is generally and perhaps rightly considered to be due to molecular or chemical energy. Atomic energy is not chemical at all, but physical, at least, when the constitutional and not the outlying electrons are in question. It is possible that the absorption of solar energy by chlorophyll in plants may also in some way utilize atomic energy, stimulated into catastrophic activity by light waves. These things are only possibilities, which observers and experimenters may do well to follow up, and, if need be, negative.

But of late an application of atomic properties in vacuo has undoubtedly been made. Ordinary electric valves depend upon the different behavior of positive and negative particles, and an electric bulb containing a positive electrode and a hot wire cathode was employed, some years ago, as a receiver for wireless telegraphy, by Professor J. A. Fleming. When the hot wire or filament is negatively charged, a stream of electrons reach the anode. When it is positively charged, the emission is checked. So, if an alternating current is received, the emission of electrons is alternatively helped and hindered, and thus the current is rectified and made capable of being received by any ordinary instrument. The cutting up into signals has to be otherwise managed, for the alternations are too quick to be acoustically perceived.

Then Lee de Forrest introduced an improvement and made it not only a wireless receiver but a relay or amplifier. Between negative filament and positive anode, in an exceptionally high vacuum, he placed a perforated grid or coiled wire, with interstices that would let the electrons through; and, instead of applying the received alternating pulses to the anode, he applied them to the grid, placed above or facing the red-hot cathode. The effect on the escaping charged particles was the same, the stream of current-carrying particles was helped or hindered, encouraged or stopped, as before; but now a strong battery could be applied between anode and cathode, and some mechanical receiving instrument, telephone or what not, could be placed in the auxiliary, or relay circuit. Weak impulses applied to the grid, according to their positive or negative sign, will now serve to control the stronger current in the auxiliary circuit; and so a received message that in itself would be hardly audible can be magnified a hundred-fold.

Electrons emitted by a hot wire are not flung off with any prodigious speed; they seem rather to evaporate off at a red or white heat; and their subsequent course is controlled by the gradient of electrical potential in which they find themselves. The force acting on them is $F = e\,d/V\,dx$, and the total work done is $F\,dx = e\,dV$; that is to say, the energy generated depends simply on the total drop of voltage through which they pass. Their speed is given by

$$\tfrac{1}{2} m v^2 = e (V - V^1),$$

and it is usually considered sufficient to specify the voltage through which they drop as adequately representing their externally generated speed.

They come off with some velocity, however, call it u; but a small opposition voltage will suffice to quench this, as gravity quenches the speed of a cricket ball thrown vertically up, and sends it down again. So it is with the electrons from a hot wire. Any potential difference greater than $m u^2/2 e$ will return it whence it came. One volt rise in potential would be able to quench a speed of 450 km. per second.

That, then, is what happens between grid and hot wire. If the grid potential is negative, and greater numerically than the minimum value, the stream of electrons from the hot wire is stopped and sent back: if the grid is positive, the speed upward of the electrons is encouraged. They shoot through the pores of the grid, they reach the anode above it, they establish connection and convey the current. The auxiliary circuit, between anode and hot wire, is completed by them, and the signal is given. But this only happens when the grid allows of their passage. If the potential of the grid is adverse they never pass through it at all, but just return depressed to the hot wire. Electric evaporation is checked, just as the evaporation of water is checked in a closed space, not because no particles spring out, but because an equal number are returned. A positive grid promotes evaporation, a negative grid checks it, an alternating grid causes an alternating stream to pass through it; and the electric stream can follow every minutest fluctuation; for their inertia is as nothing, and they respond instantly to the slightest force.

To get quickness of response the projectiles must not be allowed to bombard other molecules, so as to ionise them and render the whole atmosphere conducting. For this ionisation would not subside instantaneously, and therefore the current would not be completely under control. To avoid ionisation by impact the reservoir must be very highly exhausted, and the current ought to depend on the projectiles themselves, not on their secondary and adventitious effects.

It is to be noticed that the kind of electric emission from a hot wire differs greatly from that stimulated by ultraviolet light or X-rays. These vibratory agents dig right down into the constitution of the atom, and eject electrons whose orbital frequency agrees with their own.

The "harder" the ray; that is, the higher the frequency of the impinging radiation, the higher the velocity of the ejected electron—evidently because one of the innermost orbits is then perturbed. For in inner orbits the speed must be high, in accordance with Kepler's third law. The orbital speed varies inversely with the square root of the radius of the orbit. And the more massive the nucleus the greater the speed necessary to balance the centripetal force.

But the jostling of atoms by heat produces no such deep-seated effects. The effect of heat is as if a kind of atmosphere or crowd of stray electrons, in a metal, evaporated and escaped. It is unlikely that the electrons in a metal are really loose, but some of them are so slightly attached as to be practically loose—readily passed from atom to atom in the process of conduction and readily expelled under the irregular impulses of heat.

Whether heat is the best way of promoting this electronic emission may be doubted. It seems an extravagant method, analogous to employing an electro-magnet where a permanent magnet would do, or to supporting a roof by a jet of water. But the other kind of stimuli, such as those promoted by radioactivity or ultra-violet light, do not seem to generate the right kind of docile emission. The very high speed electrons would require too much potential to hold them down. The speed of electrons ejected by χ or γ rays is definite, and depends on the frequency of the rays; but the speed of emission of electrons from a hot body is indefinite and irregular, being distributed in accordance with Maxwell's law for a monatomic gas. Moreover, the escape through the skin of a metal is equivalent to an escape against a "contact" difference of potential; and thus, in some cases, the electrons may be said to ooze rather than to fly out, and to owe their subsequent speed entirely to the external potential gradient in which they find themselves.

That state of things would be quite convenient for wireless telegraphy, since they would then be still more readily under control. The skin retardation exerted by tungsten has been measured as 4·6 volts, unless I am mistaken.

To return to practical applications of these atomic properties—for it is atomic properties rather than atomic energy that is at present being utilized. Not only is it possible to employ a relay in the way described, for the emission and receipt of wireless waves, but one relay can be used to stimulate another; and this can be done several times in succession, and immense magnification attained; for the electric stream is so rapidly responsive and docile that it can follow fluctuations that no mechanical relay could possibly follow. The rapidity of signalling thus rendered possible in the Morse Code is surprising. Of course an automatic sender, and some form of chemical or quick-responding receiver, must be used; and then the message can be as rapid as one can speak. The words are spelt out, without abbreviation, in dots and dashes; and yet the words come on to the tape at 300 a minute, five a second or thereabouts.

It is also becoming well-known that Morse signals need not be used, but ordinary speech itself can be thus wirelessly but electrically transmitted, with quite good clearness of articulation. Every auditory frequency is slow compared with what the atomic projectiles can follow, hence every variety of speech sounds, vowels and consonants, can be readily picked up and transmitted into electric fluctuations. This is done at the sending end, and the aerial accordingly emits waves, which, though they have their own electric rate of vibration, succeed one another in batches corresponding to the acoustic frequencies. At the receiving end of the succession of waves are picked up by the aerial there, and once more converted back into telephonic speech through the mediumship of one or more valve relays and appropriate devices.

There are many details, and great ingenuity has been expended in bringing this method of wireless telephony to the perfection which it has thus far attained. The whole thing is most hopeful, and splendid work is being done at wireless research stations. I have recently seen the Government one at Woolwich, under Colonel Cusins, and a devoted staff of workers, and have gone over it with great admiration.

The interest to us, here and now, is that it is by the harnessing and practical utilization of purely atomic properties, that all this great advance in practical electrical engineering has been accomplished. The conclusion is inevitable that much more remains to be done.

Effect of Limiting Output.—In the January Engineering Review, London, Mr. Andrew Stewart, director of the Consolidated Pneumatic Tool Co., Ltd., gives his impression of a recent visit to Germany, during which he had opportunities of closely studying the industrial and economic situation. Regarding the effects of limitation of output in the engineering and metallurgical industries he has the following to say: The 8-hour day is compulsory, and in many cases the hours of work are 7 a. m. to 12:15 and 12:35 till 3:30. Work ceases altogether at this hour, though the technical and clerical staffs, who start later and usually stop from 12 till 2 in the middle of the days, in accordance with the custom on the Continent, continue to work till 5 or 6 p. m. An 8-hour day is, however, compulsory for all employes, whether clerical or technical. The claim that a worker will produce as much in 8 hours as in 10 hours is not borne out in practice; perhaps he can, but he won't; and today the average hourly output is less than half what it was in 1914. That is to say, with the 8-hour day the German worker has not even maintained his hourly output. Figures for several engineering works show that the worker of today produces 48 to 55 per cent less per hour than in pre-war days. Taking the 8-hour day into account as well as the reduction in amount of work done per hour, it will be seen that today the German workman is producing only 37 to 40 per cent of his weekly pre-war output. The reduction in the amount of wealth produced is very great, and it inevitably reduces the supply of commodities and raises the cost of living; in fact, it hits the worker far harder than it hits the capitalist.

Maintenance of Way Work on London Underground Railways

By A. R. COOPER, Engineer Underground Railways

From The Railway Engineer.

The standard railway practice is to examine the property periodically, and to use these inspections as a basis in preparing programs of work to be carried out during each year. These inspections, in general, relate to the structures, bridges and main works of the company, but personally I think that this policy can with advantage be extended to cover practically the whole of the property and works, including those which are constantly inspected in the course of their ordinary maintenance. On the Underground Railways a special inspection is periodically made by a man in a senior position who brings a fresh mind and a broader outlook to bear, and who makes his visit for the special purpose of constructive criticism.

On the Underground Railways special attention has been given to the question of dealing as promptly as possible with breakdowns or defects which may interfere with the train service. This matter is of special importance where a train service of 1½ min. headway is run during the busy times. Men are stationed at certain points throughout the road who are always available to attend to any defect that may occur. The importance of the type of failure determines the distance apart of these points of call or call-depots. It is customary to arrange as far as possible for the depots of the various departments—permanent way, signals and electrical equipment of track—to be stationed at the same points, so that assistance may be given by one department to another. These men carry out inspection and overhaul work, but are always in close touch with the signal cabin to which any messages for them are sent. The signalman is provided with a hooter, which he uses to call these men if required. On the Tube Railways very little, if any, inspection and overhaul work can be carried out during traffic hours, and in consequence the depots are laid out for carrying out work more in the nature of shop repairs. Log-books are provided for each depot, in which the callmen record all work carried out by them. Failures are also reported on special forms, which are sent in to the office of the department concerned.

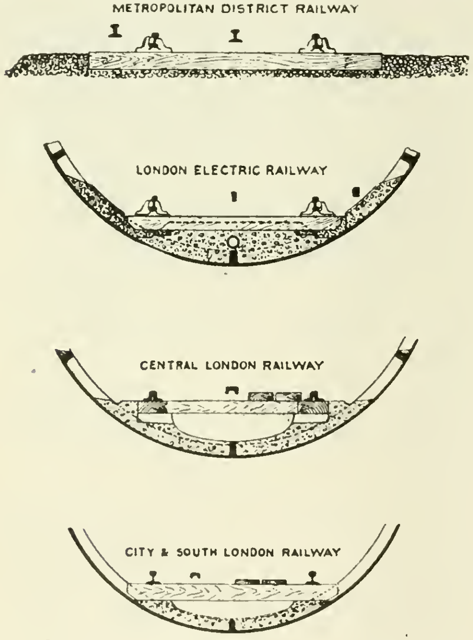


Fig. 1—Typical Cross Sections of Permanent Ways in Underground Railways.

Many defects or breakdowns require the use of spare parts, material or tools. These are kept ready at certain places on the line, their location being shown on a diagram, of which a copy is supplied to each ganger and other person concerned.

This organization covers attention to defects and breakdowns relating to the running of trains. Station defects are covered in a somewhat different way. A daily working report, summarizing defects reported by individual stationmasters, is supplied by the Traffic Department, urgent matters are reported direct to the Engineer's Department by telephone.

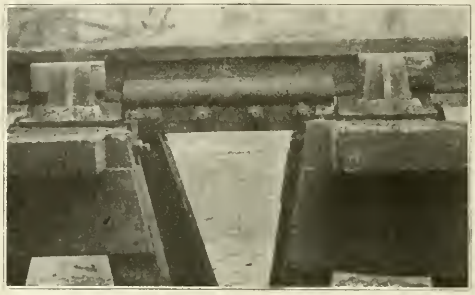


Fig. 2—Clip Fishplate as Used in Many Cases of Fracture.

A "Routine" man visits each station every 3 or 4 months. He makes a round of the station property and fittings, putting right minor defects and reporting any matters he cannot deal with; he also sees the station master, who reports anything that requires attention. In connection with this work I would emphasize what is, to my mind, a very important feature, viz., that our records of these defects (in many cases minor ones) are periodically gone through with the object of finding out weaknesses of design or construction, so that the apparatus or arrangement may be improved upon or avoided in the construction of new stations. The feature of learning from past errors of judgment is, of course, vitally important in all branches of maintenance work.

Types of Track.—There are four different types of track installed on the Underground Railways, as shown on Fig. 1:

The District Railway track, which is practically the British standard;

The City and South London, with flat-bottom rail;

The Central London, longitudinal track; and

The London Electric, which is a special type and is not found, so far as I know, on any other system.

The London Electric track is an adaptation of the British standard for use on a rigid track bed, and has given very good results. The feature of the design is that the sleeper is only supported in the center for a width of about 3 ft. 6 in., the ends of the sleeper forming cantilevers; this provides the necessary element of "spring" to overcome the hard running which would otherwise result, and serves the same purpose as rubber tires on a road vehicle. On the District Railway the rails require changing on 10-chain curves about every nine months, whereas on the 5-chain curves of the London Electric Railway no rails have yet had to be changed in the 11 years' running. There is only a loss of about 5 per cent in weight on the rail section of these curves today.

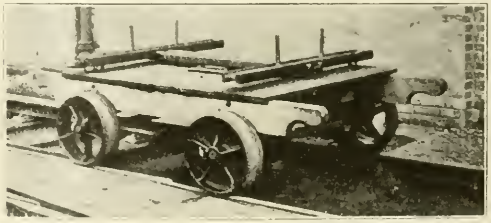


Fig. 3—Special Turntable for Turning Rails in Tunnel Sections.

As another comparison, the 100-lb. bridge rail on the 5-chain curves of the Central London Railway at the Post Office used to be changed every 9 months. The standard London Electric Railway track was put in on these curves about 5 years ago and up to the present time the results have been as good as those obtained on the London Electric curves.

In considering the form of track suitable for use on Tube Railways the question of sanitation calls for special attention. From this standpoint, ballast in any form is objectionable, as it does not allow of dirt and rubbish being easily cleared out. The longitudinal type installed on the C. L. R. has a decided advantage over cross-sleepered track in that it can more readily be brushed out. On the original track of the L. E. R. granite chippings were used at the sleeper ends as well as 1 in. deep between the sleepers. This ballast has been entirely omitted in the recent extensions, and in the older stations we have removed the granite chippings and substituted a flush concrete surface.

Reduction of Noise.—Noise on the Tube Railways is a source of frequent complaints, undoubtedly with some justification, but up to the present time our attempts to reduce it have not met with much success. The problem is quite distinct from that of noise or vibration caused in adjoining property. A case of noise in adjoining property was successfully dealt with by installing rubber pads between the sleepers and the concrete; this arrangement, while preventing noise being transferred through the tunnel lining and earth to the surrounding property, in no way lessened the noise in the tunnels. With the object of reducing noise in the tunnels ¼-in. felt pads were installed between the cast-iron chairs and sleepers; further, the coach screws holding down the chairs were insulated from the chairs themselves. Two methods of carrying this out were employed. Fibre bushes with fibre washers, are installed on 50 miles of track on the L. E. R. The second form has wood bushes with fibre washers. This form is installed on a few miles of Central London Railway. These bushes, as will be seen, are tapered and are practically similar to hollow trenails. Both types of fittings cost, at prewar prices, $136 per mile.

This feature of insulating the chair fastenings from the chairs is of importance from another aspect, viz., signal track circuiting, particularly where fang bolts are installed in wet places. The Signal Engineer of the Great Western Railway told me recently that on a troublesome track section, by installing fibre bushes, like those used on the L. E. R., the resistance had been considerably increased.

Wear on Rail Surface.—One effect of electric traction on the permanent way is to cause uneven wear on the rail surface. This occurs mainly on curves, and the hollows take place at from 2 ft. to 5 ft. centers, in some cases reaching 1/16 in. in depth in a period of 4 or 5 months. This uneven surface causes bad running, and it is necessary, therefore, to change the rails even with a reduction in section of a few per cent.

On the District Railway our practice is to take out rails as soon as hollows develop to a depth of about 3/32 in. to ⅛ in., and if these hollows do not show a reduction of section above a certain amount (about 8 per cent) the surface is restored on a planing machine and the rail put back in the road; we find that these rails have a second life as long as the first one when dealt with in this way. The following rules are observed in carrying out this practice:

Rails are not machined more than once.

Rails are not machined when such machining would entail a greater reduction of section throughout than 8 per cent.

Rails taken out from a curve if replaced in a curve are put in so as to lie in the same direction as before.

Each rail, when removed for machining, is marked to show the number of sleepers installed per rail length. It is put back in a place where it will be supported at the same points.

The last two precautions are taken to avoid reversal of stress in the rail material.

Before the war the cost of taking out rails, machining them and replacing them in the track was about $4.86 per ton, whereas new rails, making allowance for scrap value, would have cost about $24.30 per ton. About 3 miles of rail are treated in this way on the District Railway each year, or about 15 per cent of the total rail renewals.

Rail Fractures.—The effect of an electric arc on rail steel is the same as a "nick," and some of the fractures which have taken place on the Underground Railways have directly resulted from this cause.

A device which has been provided with the object of minimizing traffic delays from broken rails is the clip fish-plate shown in Fig. 2, which has been supplied to all sections. It is suitable for use on many cases of fracture, and can be fitted in a comparatively short period of time.

Special Track Work.—Electric traction is very severe on crossing and angles, and in consequence their maintenance has received particular attention. The introduction of manganese steel has been of great advantage; crossings and angles of this material have in all cases been used on the Tube Railways since about 1904 and on the District Railway at busy places. The form adopted for the Underground Railways is a casting, though some companies have in recent years made use of rolled manganese rails for building up special track work. We find castings quite suitable for the class of traffic on the Underground Railways, though I am inclined to think that for higher speeds and heavier axle loads there is much to be said in favor of the built-up construction as used, for instance, on the Great Western Ry. In the short leads which are in use at junctions on the Tube Railways the castings are arranged to connect up to each other, i. e., special attention is given to limiting the number of closures.

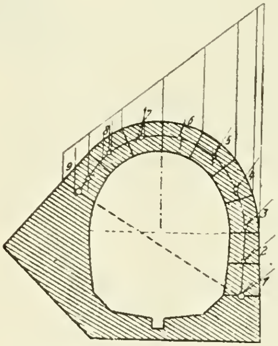
Manganese steel is a bad conductor of electricity on electrified railways where the track rails are used for the return current it is necessary to bond it across.

Special Trolley for Turning Rail.—The platelayers' trolley shown in Fig. 3 has been adapted for the special purpose of turning rails in tunnel sections, and was devised by Chief P. W Inspector Williams, of the Underground Railways. The turning of rails in the tunnel sections of the District Railway naturally involves taking them to some opening or space where there is room to swing them round. The rails are trollied to a suitable place, and formerly some 12 or 15 men had to be sent with them to carry out the turning, although the actual trolleying work would not require more than 3 or 4 men. By using this trolley 3 or 4 men can carry out the whole job, including the turning.

Reinforced Concrete Tunnel Construction on Bagdad Ry.

From Beton u Eisen, Berlin.

Two occasions arose on the Bagdad Ry. in which the reinforced concrete proved invaluable for tunnel construction. The portion of the railway on which these tunnels are located is in the Taurus Mountains, and due to the position of the track it was decided to build a tunnel of reinforced concrete and to cover this over with filled-in material, so that if any of the higher ground slipped it would not interfere with the trains.



The construction work was partly carried out in the open and to a small extent by tunneling and then building up the concrete structure to fit the tunnel.

As the work was carried out during the war and under considerable difficulties, it was decided not to adhere to the prescribed calculations, but to simplify the construction as far as possible.

The accompanying sketch shows the shape of the tunnel and its normal position relative to the surface. The thin, sloping line above it indicates the natural angle of repose of the ground material—viz., 39 degrees. The arch at the thickest part is 3 ft. 6 in., and the true moments are as follows:

1 +16:9 mt.
2. + 6:9 mt.
3. — 0:6 mt.
4. — 8:7 mt.
5. — 9:9 mt.
6. + 8:2 mt.
7. + 9:4 mt.
8. + 3:3 mt.
9. —14:4 mt.
10. —24:6 mt.

The moment-zeros are near point 3, between points 5 and 6 and between points 8 and 9. At these points the steel reinforcement is bent to an angle of 45 degrees.

New Filtration Plant of Madras City Waterworks

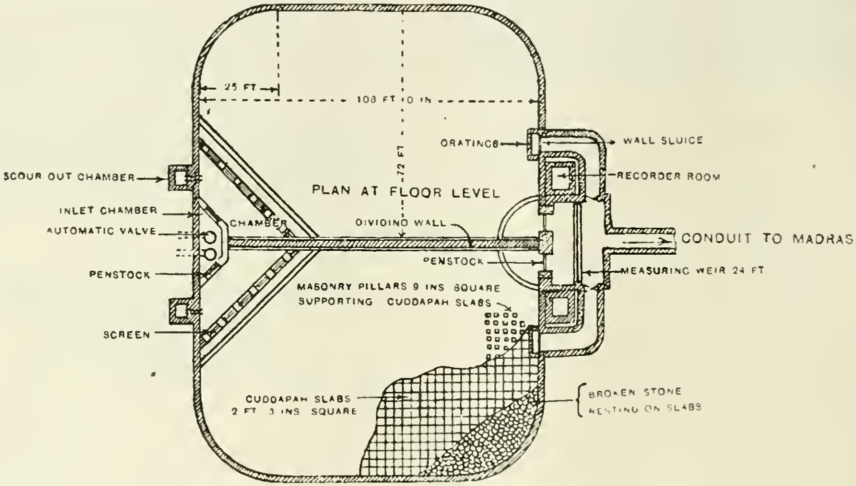
By JAMES WILBY MADELEY.

From Water and Water Engineering, London, Dec. 20, 1919.

Screening Chamber and Roughing Filter.—The two 24 in. pipes from the intake tower pass under the tank bund, and terminate in a screening chamber. To regulate the supply, automatic valves actuated by floats were provided, arranged to close when the water should rise above the level necessary to give the requisite flow through the conduit. These proved unsatisfactory, and the regulation is now performed by hand.

The walls of the screening chamber are fitted with movable copper gauze screens, 3/32 in. mesh, having a total area of 125 sq. ft., through which the water must pass in order to reach the roughing filter.

After leaving the screening chamber the water enters the roughing filter at floor level, and rises through a filtering medium consisting of broken stone supported by stone slabs, which rest on brick piers. It then flows over a measuring weir into the conduit. The quantity of water flowing over the measuring weir is automatically recorded on a diagram attached to a drum actuated by an eight-day clock. The head is translated into flow by means of a "Hutchinson" recorder. Two by-passes are provided, so that the water can be passed directly into the conduit without filtration, should the surface of the lake sink below the level required to pass the full supply over the measuring weir.



Screening Chamber and Roughing Filter at Red Hills, Madras City Waterworks.

The roughing filter is a chamber 150 ft. long, 108 ft. wide and 8 ft. deep. The floor is of concrete and the walls of brickwork. It is divided into two compartments, governed by penstocks, so that one half may be thrown out of action for repairs or cleaning, while the other half remains in use. Ordinarily cleansing is effected by reversing the flow through the filter.

The filtering medium consists of 3 ft. of crushed trap rock, varying in size from that which, at the bottom, will just pass through a 1½ in. ring, to the top layer, which will pass through a ¾ in. ring and be rejected by a ⅛ in. ring.

The screening chamber and roughing filter are surrounded by a brick wall, 3 ft. high, to keep out animals, or leaves and other materials which would otherwise find their way into the water.

Filters.—In all, 21 filters of the ordinary slow sand type were designed. Of these, 14 have been constructed, arranged in two rows of seven each, the intention being that six filters of each row 12 in all—should always be in operation, allowance being made for one filter in each seven to be out of use for cleaning or repairs. Owing to the economies necessitated by the war, the construction of the remaining seven filters has been postponed. The conduit which brings the water from the Red Hills is continued round the 14 filters, and is connected to each bed by a 14-in. diameter cast iron pipe, controlled by a valve, so that any filter may be isolated for cleaning or repair. Between the two rows of filters runs the filtered water conduit, to which filtered water is delivered separately from each bed. Each filter is 200 ft. long and 100 ft. wide, this being a convenient size for cleaning without throwing out of use too large a filter area at a time. The floor consists of concrete 1 ft. 11 in. thick. The bottom layer, 1 ft. 6 in. thick, is in combination mortar, and forms a continuous slab under each row of seven filters. On this slab are built the walls of brickwork in combination mortar, with a stone coping. The top layer of the floor concrete is in cement mortar and extends over the bottom slab in the area between the walls.

Below the top-of-sand level the walls are slightly battered on the inside in order that the sand, by its own weight, may be packed tightly against the walls, and thus prevent the free passage of water between the sand and the walls. As a further precaution against this "water-creep," both the drains and the broken stone at the bottom of the filters are stopped 3 ft. away from the walls; broken stone is placed round the ends of the drains and the space between the stone and the walls is filled with sand.

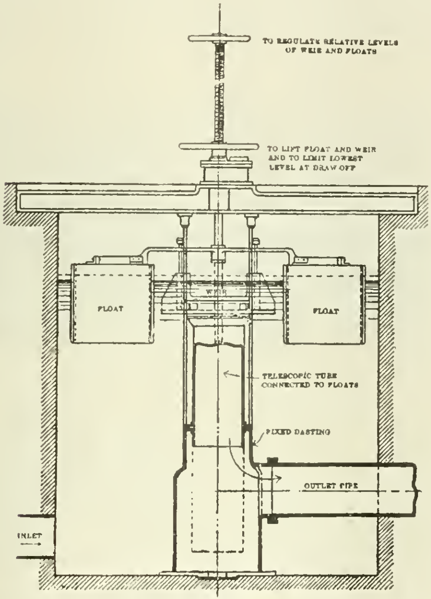
Filtering Materials and Drains.—The filtering materials consist of clean siliceous river sand, 28 in. deep, screened to eliminate as nearly as practicable all material except that which passes through 1/30 in. mesh, and is retained on 1/50 in. mesh. It contains a small proportion of finer stuff which could not be excluded.

Under the fine sand layer is a layer of coarse sand 2 in. deep, resting on broken granite laid in two layers, each 2 in. deep. The coarse sand is screened so that its grains will pass ⅛ in. mesh sieve and be retained on a 1/30 in. mesh sieve. The top layer of stone will pass a ⅜ in. ring and be retained on a ⅛ in. ring. The bottom layer will pass a ¾ in. ring and be retained on a ⅜ in. ring.

The sizes of the coarse sand and the thicknesses of the stone layers were fixed after experiments on a small trial filter had shown that they were the shallowest layers which could safely be trusted to support the fine sand layer without allowing any of it to percolate into the filter drains. The stone layers were made shallow not only with a view to economy, but because in a climate like that of Madras and with the Madras water it is important to keep the layers as shallow as possible in order to reduce the "post filtration" multiplication of bacteria to a minimum.

Below the bottom layer of broken stone are the brick drains consisting of two layers of best pressed brick laid flat. In the bottom layer, which rests on the concrete floor, the bricks are laid end to end in rows 4½ in. apart. Beginning 3 ft. from the side walls, they are laid to the main drain running along the center of each filter, and form drains 4½ in. wide and 3 in. deep. In the top layer the bricks are laid across the drains so as to form a continuous surface, broken only by the narrow slits due to the irregularity of the bricks. It is through these slits that the water makes its way to the under-drains. The main drain is semicircular, 24 in. wide, and is covered by stone slabs 2 in. thick.

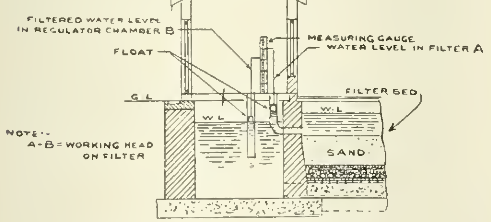
Filter Outlet Regulator.—The main drain leads to the rectangular filter outlet chamber, which contains a Glenfield-Jones automatic outlet regulator, the object of which is to maintain a constant rate of filtration. Each of these regulators consists of an outlet pipe 14 in. in diameter capable of sliding up and down inside a closely fitting cast iron pipe fitted with a flat base, which is bolted down to the floor of the chamber. This has a right-angled branch through which the filtered water passes to the filtered water conduit.


TO REGULATE RELATIVE LEVELS OF WEIR AND FLOATS
TO LIFT FLOAT AND WEIR AND TO LIMIT LOWEST LEVEL AT DRAW OFF
FLOAT
WEIR
FLOAT
TELESCOPIC TUBE CONNECTED TO FLOATS
FIXED CASTING
OUTLET PIPE
INLET

SIDE VIEW

Automatic Filter Outlet Regulator.

At its top the sliding pipe is fitted with two weirs, each 15 in. long, attached to galvanized iron float tanks, so arranged that the outlet can be made to discharge a maximum of 1,100 gals. per minute. This is equivalent to 152 vertical inches per 24 hours. The apparatus can be set to deliver at any rate below the maximum. The standard rate is 96 vertical inches per 24 hours. This apparatus ensures a constant flow through the filters until the weirs have reached their lowest points of travel, when the rate of filtration steadily diminishes, and it becomes necessary to clean the filters. The travel of the telescopic pipe is slightly more than 2 ft. 6in. The depth flowing over the weir is determined by measuring the depth of the water surface from the top of the weir side plate. A hand wheel actuating a screw is provided, by which the telescopic pipe weirs can be raised or lowered relative to the floats, thus reducing or increasing the rate of filtration.



Method of Measuring Filter Head.

To show the head on the filter two vertical pipes are carried side by side up the outlet regulator chamber walls. One pipe is connected with the filter above sand level, and the other with the water in the outlet chamber. In the pipes are floats carrying pointers, which move up and down a fixed scale. The difference in the readings of the two pointers, which are of equal length, gives the head on the filter.

Filtered Water Tanks.—The filtered water flows into three underground covered tanks, each 150 ft. square with a depth of 10 ft. of water, having a capacity of 1,400,000 gal. each.

The floor consists of 2 ft. of concrete in combination mortar. The side walls are of brickwork in combination mortar rendered on the inside faces with cement mortar. The roof consists of brick jack arches springing from steel girders, supported on brick cross walls, which are carried by arches springing from granite piers. Access to each tank is provided by means of manholes. Vent pipes provide inlets and outlets for the air which continually enters and leaves the tanks as the water level falls and rises.

Each tank is provided with inlet and outlet pipes. Both are 30 in. in diameter, and are fitted with sluice valves so that any tank may readily be isolated for cleaning or repairs without interfering with the working of the other tanks. A scour is also provided for each tank.

Industrial Progress Dependent on Alliance of Science and Industry

From The Engineer, Dec. 19, 1919.

Speaking at a conference of representatives of research organizations connected with the Department of Scientific and Industrial Research at the Institution of Civil Engineers on Dec. 12, Mr. Balfour said it was evident the industrial progress of mankind in the near future would more and more depend upon the alliance of science and industry and upon the co-operation of different branches of science with each other. The great industrial development in which Great Britain led the way towards the end of the eighteenth century—that gave her a manufacturing supremacy over the world, which it is certainly impossible, and probably not wholly desirable, that we should ever regain—was not in the main due to anything which pure science contributed to industry; and he believed that it was partly owing to that fact that the great industrial community of this country failed to see as fully as was desirable that science was an essential element in industrial progress.

The Germans, whose industrial development came much later, took a different view. He did not think that they showed any greater aptitude for science than Britons; but, beginning as they did rather late in the day, with their great powers of governmental organization, with their highly developed and equipped universities, and with the view which they had always entertained of the close alliance that ought to exist between knowledge and power, they naturally and easily did what we, with more difficulty and at a later date, were beginning to do. They saw how close was this co-operation, how absolutely necessary it was, not merely in the competition of people with people, of industry with industry, but they recognized, too, that it was only upon our increasing knowledge of the powers of nature that we could expect to improve the material lot of man. The thing, continued Mr. Balfour, which was really going to make a difference in the future, to make the remainder of the twentieth century different from the nineteenth century, and the twenty-first century different from the twentieth, was the command, for industrial purposes, which man had over the forces of nature. That could only be attained, in the first place, by the cultivation of pure science, of science for itself, of knowledge for its own sake. It could only be if we strove to breed and to educate men who, without any thought of self-advancement, were consumed by a curiosity to know, and, that end having been attained, then to learn how to apply the knowledge which they had disinterestedly acquired to the great purposes of industrial development.

Re-Oxygenerating Water for Public Swimming Pools.—By re-oxygenerating and filtering the water of its 33 public swimming pools and using it again instead of fresh water, the city of Manchester, England, has effected a saving stated to amount to 2,000,000 gal. of water annually.

Experiments on the Horizontal Pressure of Sand

By PONSONBY MOORE CROSTHWAITE.

Abstract of a paper read before the Institution of Civil Engineers, Feb. 10, 1920.

Recently the author made a series of experiments to ascertain the angle of internal friction in sand, clay and other materials by loading a plunger of known diameter and measuring the penetration caused by known weights. The value of ϕ, the internal angle of friction, was calculated from Rankine's formula:

$$d = \frac{P}{W}\left(\frac{1 - \sin\phi}{1 + \sin\phi}\right)^2$$

when d is the penetration in feet, P = the pressure per square foot, W = the weight of the material per cubic foot.

The angle of internal friction from these experiments was much less than the angle of repose, and was not constant for any one material, but depended on its state of aggregation, whether it is put loosely together, shaken or consolidated by tamping.

The conclusion he arrived at was that walls calculated by Rankine's theory, which assumes the "angles of internal friction" and the "angle of repose" to be the same, would have a factor of safety of from 2½ to 4. In order to test this conclusion, a number of experiments were made in which the pressure of dried sand against a model wall was measured. The first experiments were made with a vertical door backed with sand and hinged at its lower edge, the tension in a string necessary to keep it in position being measured. Experiments were made: (1) With the sand lightly poured into the box of which the hinged door formed one end; (2) with the sand thoroughly stirred together (3) with the door surcharged to an angle of 30 degrees, the angle of repose of the sand being 35 degrees; (4) with the door surcharged to different angles.

These experiments proved that the pressures calculated by Rankine and Colomb were much too high, especially for the surcharged wall.

At the same time experiments were made to test the wedge theory. A false bottom coated with glued-on sand, was provided that could be set at any angle with the back of the wall, so that the pressure produced by any wedge could be measured. These experiments proved that the wedge theories of Darwin, Boussinesq, Brightmore and others, that take into account the friction between the back of the wall and its backing, give correct results for the wedge of maximum thrust so long as the wall is not surcharged, but that it breaks down altogether when applied to a surcharged wall, the calculated pressures being 30 per cent too great; also that wedges making a small angle with the back of the wall produce a greater pressure than calculation by the theory gives.

These results made the author think that something was wrong with the theory, and it occurred to him that it might not be right to take into account the friction between the wall and backing. He therefore modified the equation by which the pressures had been calculated, neglecting the friction between the wall and backing, and introduced into it an angle of internal friction instead of the angle of repose.

The angle of internal friction was arrived at by calculating what angle would satisfy the maximum pressures observed for the unsurcharged wall for the sand lightly put together and well stirred together. These angles, instead of being 35 degrees, the angle of repose, were 42 degrees, 20 minutes and 49 degrees. These angles were then used for calculating the undivided wedges, the results coming out in marked agreement with the experiments. The angle 42 degrees, 20 minutes was then used to calculate what should be the pressures for the surcharged wall, with the result that there was the same agreement, the maximum calculated pressure being practically identical with the observed.

The author then carried out experiments to definitely test if wall friction did actually affect the horizontal pressure or not. For this investigation new apparatus was used.

A long box was cut into two compartments by a vertical saw cut transverse to its length. One-half was fixed to solid supports, the other being carried on live rollers. When the box is full of sand the two compartments are urged asunder by the pressure of the sand on the plane passing through the saw cuts. This is the pressure on Rankine's ideal plane, and it was determined by measuring the tension on a string that prevented the rolling half of the box from being pushed forward. The rolling box was then turned end for end, so that the sand in the fixed compartment was held in position by the solid end of the box, the face of which was coated with glued-on sand. This is the same as if it had been retained by a rough wall, and if friction between the wall and backing affects the amount of the horizontal thrust the amount of the tension now required to keep the rolling box in position should have been less than before. A large number of experiments were made, and it was found that there was practically no difference, and proved, so far as laboratory can, that it is not correct to assume that friction between the wall and backing can affect the amount of the horizontal thrust.

The results of all the author's experiments prove that the angle of internal friction is considerably greater than the angle of repose, and that it varies with the state of aggregation of the material. Also that the latter is a physical constant that relates only to the surface where the particles are free to rotate, but that at the interior of the mass it is the angle of internal friction that determines the stabiliy. It is therefore unlikely that any theory can give correct results which only takes into account the angle of repose. In Darwin's paper on the "Horizontal Thrust of Sand,"* he says that "the maximum internal friction in various parts of a mass of sand is not constant at all;" but nevertheless he uses the "angle of repose" as the "angle of internal friction," and tries to make his theory fit in with his experiments by introducing wall friction.

With regard to his apparatus used in his experiments, the author found that the wall on live rollers worked extremely well, and believes that it could be designed to measure the pressures against a wall 10 ft. high and 10 ft. wide. With such apparatus it is suggested that it would be possible to investigate clay backings, which are not likely to be amenable to treatment in such small apparatus as was used in the present experiments.

The conclusions the author would draw from his investigations are:

1. That the plane of rupture may be a convenient mathematical fiction, but has no existence in the granular material dealt with—at least, he was unable to trace any evidence of it in his experiments.

2. That the angle of repose is a physical constant that relates only to the surface, and is represented in the interior of a mass of sand by the angle of internal friction.

3. That the angle of internal friction is not a physical characteristic constant for any one material, but varies with the state of its aggregation.

4. That friction between the back of a wall and its backing does not affect the amount of the resultant thrust.

5. That the wedge theory which takes into account wall friction and the angle of repose, though giving correct results when applied to a wall without surcharge, or with a negative surcharge, breaks down completely when applied to a surcharged wall.

6. That the wedge theory when modified by leaving out wall friction and introducing, instead of the angle of repose, the angle of internal friction gives correct results in all cases, whether for the maximum thrust or that produced by individual wedges.

Finally the author draws attention to agreement of his experimental results with the conclusions of Sir Benjamin Baker, who states from his experience that to retain loose earth, walls designed to withstand liquid pressures of 10 lb. to 20 lb. per cubic foot are sufficiently strong. The author's measured pressures for loose earth correspond to a liquid pressure of 18.4 lb. per cubic foot, and for well-stirred sand 14 lb. per cubic foot. The former is probably as great as would be produced by loose earth, and the latter considerably greater than that, due to damp earth or sand. This coincidence is remarkable, considering the extremely small scale of the author's experiments, and that Sir Benjamin Baker's conclusions are drawn from considerations of works of the largest size.

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*Min. Proc. Inst. C. E., Vol. lxxi, Part I.

Elliptical Vaulting As Primary Factor in Contemporary Architecture

By MAURICE S. R. ADAMS

From Concrete and Constructional Engineering, London; abstract of a paper presented Dec. 18 before the Concrete Institute.

Concrete, as developed by modern science, I conceive as being the finest structural building material the world has so far produced. Its chief advantages are adaptability, great strength, durability and monolithic character. The age of concrete building has not yet begun, and I foresee great possibilities for a future style of architecture, when the real characteristics of concrete are realized and the true principles of architecture are revived.

Interior of a Factory Model.

The culminating point in all systems of construction and styles of architecture is the problem of roofing. Even where the roofs are flat the problem is not so simple as might at first be imagined, because when spans exceed more than moderate size, it is necessary to introduce secondary beams or girders, and these result in the application of concentrated loads at fixed points, instead of being evenly distributed over the walls. Such loads, augmented from floor to floor, must necessarily have considerable influence on the plan, and must be carefully considered at the outset.

The walls in ordinary buildings serve two purposes—namely, to support the roof and to screen the sides.

Advantages of Elliptical Vaulting.—An advantage of semi-elliptical vaulting is that the vaults may spring immediately from the floor level instead of being superimposed at a higher level upon walls or piers, as in Gothic architecture. Thus all thrust is absorbed at the ground level and no system of buttressing is required. Further, the vault or roof being thus self-supporting, all structural or weight-bearing walls are eliminated from the building. The gable walls closing the ends of the vaults are in effect panels rather than walls, and consequently their thickness may be reduced to that of a partition. I have built gable walls to cottages only 4½ in. thick; but from the fact of their being tied in by the concrete vault they possess remarkable strength, and the result is more permanent than a brick wall of twice the thickness as used in ordinary construction. Buildings roofed with elliptical vaults are in reality all roof.

The remarkable stability of vault construction, whether of stone or concrete, lies in the fact that the vault substance is built, not vertical, but falling, and consequently the direction of gravity cannot be changed by any slight settlement in the foundation. The very weight of the material used serves to increase the vault's strength. Within the limits of compressional strength a vault may be uniformly loaded to any extent desired. The loaded vaults will be actually stronger than the unloaded vaults. Very different is the case with beam construction in which tensional strength is strictly limited within a comparatively small margin of safety. Any surplus overloading at once reduces strength, and places stability in danger.

The extraordinary strength and durability of Gothic vaulting are due to these facts. The old Gothic builders were masters of construction.

A simple cross vault consists of four arched compartments, each of which tends to topple inwards. The four compartments exactly counter-balance each other, resulting in great constructional strength compared with the amount and weight of material employed. Any tendency to spread in one compartment is exactly counter-balanced by the same tendency in the adjoining compartment.

The first point in favor of semi-elliptical vaulting is that greater strength is produced with less material than is possible with any other form of construction, and it is therefore scientific and true to nature. For this reason it may be adopted for architectural purposes as considered from the present point of view.

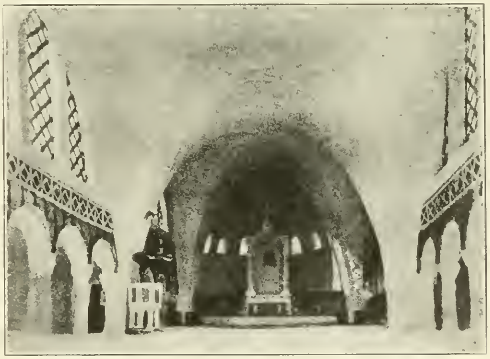
I include as semi-elliptical all curves approximating to this form, such as parabolic and pseudo-elliptical curves.

It is, of course, desirable with all forms of roofing that the loads thereon should be supported at as few points as possible, that the plan may not be unduly interfered with. By steel construction the number and size of the stanchions or piers may be reduced to a negligible quantity. With cross vaulting the results in this respect are at least equal, and in some cases superior, to steel beam construction, since the floor space is entirely unrestricted, save at the four corners of each bay. By means of reinforced concrete the bays may be of any size desired, the construction requiring less material and giving greater strength than would be possible by any other means.

Architectural Considerations.—Architectural expression may be divided into two classes; constructional forms and ornament or decoration. In designing, the architect must thoroughly understand the requirements and purpose of his building, since practical considerations come first and foremost. To solve successfully the problem he must meet these requirements both in letter and in spirit. Practical considerations of minor importance must be made subservient to first essentials. Nothing must be intentionally disguised or falsely expressed.

Having thoroughly grasped the requirements of this building, the designer will consider questions in connection with the site, aspect and prospect, the nature of the soil, and any differences in level, so that his plan may serve to the best advantage.

In recent years a strange and wholly illogical doctrine has arisen, which teaches that design has nothing in common with the construction, and that the best architects are those who most successfully disguise modern steel frame construction with applied architectural forms. Modern construction, we are told, must necessarily be very ugly if left to express itself naturally.



Interior View of Model of a Church.

Works of architecture should be designed from the inside and not from the outside. The internal form of a building will be determined by practical considerations and structural necessity. The outside of a building may be left to take care of itself, when it will express quite naturally the form of the interior and true shape of the building.

There are three kinds of proportion in architecture—the vertical, the horizontal and the neutral or square.

With the former methods of construction only three pure styles of architecture were possible—namely, the Greek or horizontal style; the Gothic or vertical style; the Byzantine or square style. All other periods of architecture were impure in style in varying degree measured by the departure from the basic proportion adopted.

With new methods of monolithic construction in reinforced concrete, three new and pure types of design became possible, opening up a wider field for design than the world has ever seen. We can at first do no more than start on the same principles from which all the great styles were evolved. If we do what we at least conceive to be right we need not fear criticism in an age when the very principles of art are so little understood.

Designs and Buildings Constructed with Roofs of Semi-Elliptical Reinforced Concrete Walls.—Design for a War Memorial Church.—Mention may be made that it was in trying to solve the problem of modern church design that I hit upon the idea of elliptical vaulting.

Funds available for church building, in the majority of cases, were far too small before the war. Now, with the cost of building increased three or four times, the task of building on pre-war methods becomes impossible.

The plan of my concrete church is essentially modern, and adapted to modern needs.

The nave is wide and no piers or columns obstruct the view of altar or pulpit. The chancel and sanctuary are wide and spacious.

The building is simple in form, consisting of three square bays covered by semi-elliptical vaults, which spring immediately from the floor level, and which consequently produce no thrust. The nave is 40 ft. wide, and 40 ft. high measured inside from pavement to crown. It is therefore of neutral or square proportion. Square proportion is recognized throughout the design, as in the semicircular arches of the arcades and in the spacing of the columns; in the semicircular and lozenge-patterned tracery of the clerestory windows; and in the design of the marble pavements and marble decorations of the arcades. In this regard the design bears resemblance to Byzantine architecture; but since the materials and mode of construction employed are essentially different, the treatment cannot with any degree of accuracy be termed Byzantine. The elliptical cross vaulting as here employed when carried out in reinforced concrete would produce a building of exceptional strength and durability besides being very economical in material. The curving of the vaults tapering inwards gives the effect of increased height by intensified perspective.

Externally the form of the building is produced naturally by the vaulting. No attempt is made at disguise, and since concrete may now be rendered waterproof, no roof mask is required as in Gothic architecture.

Other Buildings.—Elliptical vaulting may be employed to advantage for all classes of buildings requiring large covered areas of low proportion free from obstructions, such as factories, stores, tram sheds, etc. In these cases the ellipse is placed on the long, instead of the short, axis as in the case of the church.

To illustrate this type of building I have designed and modeled a factory building.

The factory consists in plan of three rows of four bays each 30 ft. square. The shop therefore measures 120 ft. long by 90 ft. deep with a height of 15 ft. from floor to crown of vault. With this form of roof only six internal columns are required, and these are spaced at 30 ft. intervals. With ordinary steel construction the girders supporting roof principals would necessarily be very heavy over so wide a span and intensified by the irregularity of the loadings from the more closely-spaced roof principals.

The entire absence of dust pockets makes a vaulted workshop very sanitary. Such buildings are readily cleaned, and when desired may be washed out with a hose pipe.

In the example, top lighting is arranged in the north compartment of each bay. Other methods are possible, such as by means of lanterns placed over the center of each bay. Ample side lighting is arranged on all sides of the shop.

Office and lavatories, etc., are arranged along the west side of the shop with separate entrances and check offices for men and women. Sliding doors are provided at both ends of the building to facilitate the handling of goods on receipt and despatch.

Naturally as an architect I am primarily interested in the architectural aspect of building, but it so happens that it is possible to erect houses by my system of reinforced concrete construction both more cheaply and quickly than by ordinary methods of building. Unlike all other systems of construction which aim at economy by reducing the amount of material employed, and which must, therefore, be considered as being more or less temporary, my cottages, owing to their form of construction, are absolutely permanent.

The first bungalow has been erected at Ruislip Middlesex. The design of this and other bungalows has been standardized in order that the greatest economy may be effected. The living room measures 21 ft. 6 in. by 17 ft. 6 in. by 9 ft. 6 in. high. This is much larger than is usual for so small a cottage and forms the principal feature of the house.

Similar bungalows are in course of construction at Herne Bay and Hounslow and a number of others are to be built at Broadstairs, Bexhill, Bushey and Ruislip.

Constructional Methods.—The Ruislip bungalow has a roof constructed of self-centering metal reinforcement attached to steel diagonal ribs. The gable walls or panels which close the ends of the vaults are of hollow concrete blocks trimmed in execution to a wooden guide. The walls are finished with sirapite plaster inside and Pudloed cement outside, distempered white. At Ruislip I omitted all foundations, merely stripping the turf and forming a reinforced concrete raft over the site. The brick fireplace in bedrooms proved expensive; therefore, in all other cases, gas fires have been substituted in the bedrooms, the flues being taken up in the partitions to a brick stack carried on the concrete vault. The omission of the brickwork effects a big increase in the floor space, besides reducing the cost. Self-centering temporary supports about 4 ft. apart are all that is required, thus obviating all close-boarded forms. Thorough tamping with reinforced concrete work is essential, and I found the self-centering rather apt to be springy and throw back the concrete during the tamping, especially on the sloping surfaces of the vaults. At the lower portion of the vaults, where some form of external form would be necessary to keep the moist concrete in position, the difficulty was overcome by building up a casing with 2-in. concrete slabs in place of the forms. This method proved quite satisfactory.

At Herne Bay a special form of climbing wood shuttering was designed for use in place of the concrete blocks in the gables, so that the gables might be cast monolithic in situ. The time, however, required to erect and take down the shutters more than counter-balanced the advantages of this method. I have, therefore, reverted to the use of concrete blocks.

For purposes of economy and facility in execution I have cut out the whole of the steel reinforcement in the construction of my vaults. The vaults are constructed with pre-cast reinforced blocks 4½ in. thick. These are specially cast in constructed boxes by a method which gives the blocks the proper curve required and also the correct mitre at the ends next the diagonal lines of the vaults. Eight casts are required to each bungalow, and this may be done by two laborers in eight days, or by four laborers in four days. The blocks are cast in stacks and may be unstacked after about four days. They require at least seven further days to mature before use.

One of the secrets of successful house construction in concrete is the use of a suitable aggregate. For my cottages I use either washed pan breeze or crushed clinker, which must be reasonably free from sulphur. No sand is required with these aggregates, which, when mixed with cement in the proportion of 1 to 6, make a splendid building material. The substance is too porous and breathes too freely for sweating to be possible, and is, to my mind, superior to brickwork for house construction. The concrete must be fixed fairly dry and thorough tamping is essential. In wet weather watering of the blocks is unnecessary; in fact, the difficulty is rather the opposite since the blocks take too long to mature if kept saturated. In hot summer weather, however, sprinkling is necessary for a few days after manufacture to make up for evaporation, and the blocks must not be allowed to dry white too quickly.

For my bungalows the roofs are finished either with thatch, or tiles, or merely rendered with Pudloed cement or granite and cement. The rendering should not be applied as a continuous covering, but should be divided up into squares of 5 or 6 ft. by means of a paper joint which may be subsequently filled with hot mastic or some composition such as "Matex."

Subsoil Water in Relation to Tube Wells for Irrigation

By T. A. MILLER-BROWNLIE,
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From Indian and Eastern Engineer, Calcutta, December, 1919.

During the past 10 years considerable development in lift irrigation, by means of the wells, has taken place in India, and judging by the success of most of these installations there is every prospect of a great future for this type of irrigation.

Observation of a large number of existing tube well installations has led me to conclude that the engineers responsible for carrying out these works have never examined the conditions governing underground water supply and therefore more or less frequent alterations in each installation have had to be made in order to maintain the discharge obtained in the early days of the plants installation.

Observations made during the past few years of the subsoils of the Punjab have shown that the slopes necessary to cause water motion have varied from 1 in 260 in moderately coarse sand to 1 in 175 in fairly fine sand. In gradients flatter than this in each type of sand there is no apparent motion. Capillary attraction interferes with the true flow and investigation into the forward motion becomes greatly involved. Observations indicate that any lateral or forward motion of water, where the hydraulic gradients are slightly less than those mentioned, is so slow that for practical purposes it may be neglected, the actual velocity probably not exceeding a few inches per day. When water is flowing through sand the hydraulic gradient is a straight line as long as the sand is all of similar grade and density and all cross sections on the line of flow are of equal area.

This may not be perfectly clear, but if likened to a pipe of uniform bore discharging from an open end, the fact becomes obvious.

In a long pipe of gradually diminishing diameter discharging water, the hydraulic gradient for this becomes a curve. The large diameter of pipe at the upper or reservoir end has a hydraulic gradient of slight slope, the next section of pipe of slightly smaller bore requires a greater head to overcome its friction and the hydraulic gradient is steeper—and so on to the final section of small bore pipe which requires a considerable head and thus a very steep hydraulic gradient to overcome its friction. Exactly the same takes place in sand when the water flow is concentrated on a point as in a well. The waterway area through the interstices of the sand is gradually diminishing and hence an increasing head is required to maintain the discharge as the water approaches the well. Thus we have the curved line generally referred to as the cone of depletion for wells, tube wells, etc.

When pumping is first started on a tube well the hydraulic gradient is steep, but this is artificial only, and as the water is gradually withdrawn from the cone thus formed, the gradient gradually flattens out and on reaching its limiting hydraulic gradient the supply ceases; this may take several months according to the amount of depression provided for, it being only a question of the rate of pumping compared with the capacity of the cone reservoir. What has apparently never been done is to estimate the source of water supply and provide an area sufficiently large to accumulate the quantity of water required for the discharge. In many districts direct percolation from canals and rivers provides a large portion of the underground water supply; this can be gaged and therefore I will only consider those districts where the hydraulic gradient is flatter than the limiting hydraulic gradient and in which rainfall is the only source of supply.

Assume that a tube well is required with a constant discharge of 1½ cu. ft. per second, the annual rainfall of the district being 26 in., of which one third is absorbed or say 9 in.; 1½ cu. ft. per second of water flowing constantly for one year amounts to 47,304,000 cu. ft. and this being supplied by 9 in. of rain requires an area of 63,000,000 sq. ft. A circle of this area would have a diameter of 8,920 ft. approximately. With a limiting hydraulic gradient of 1 in 200 on a radius of 4,460 ft. the depression head amounts to just over 22 ft.; to this must be added approximately 5 ft., the head required for the trumpet mouth portions of the cone, to overcome the increased friction as the water approaches the tube.

It will be observed that I have calculated the cone as having straight sides and have added a few feet for the trumpet mouth portion of the cone. The influence of the trumpet mouth is only observed a few hundred feet from tube, the remainder of the curve being so nearly flat that it may be considered the straight lines of an unrestricted hydraulic gradient. The error thus introduced is slight and the calculations very considerably simplified.

In conditions as mentioned above it will be observed that for a permanent discharge of 1½ cu. ft. per second, a total depression head of 27 ft. should be provided for, and the cone of influence will be over 1½ miles in diameter.

The actual quantity of water stored in this depression cone is as follows:

Volume of cone is roughly 462 million cubic feet and quantity of water stored in this grade of sand is 30 per cent or 138 million cu. ft.

In the above example I have assumed the subsoil water surface to be level; this seldom occurs, but when there is no subsoil water motion, the hydraulic gradient is less than the limiting gradient and with a slope of any degree the cone would form an ellipse for its base. In dealing with these slight gradients the assumption that the base of the cone is a circle instead of an ellipse simplifies calculation and the error introduced is negligible.

Although provision has been made in this example for an ultimate depression head of 27 ft., it will be some considerable time before this head is reached. In the first year of pumping 47 million cu. ft. of water will be withdrawn from the subsoil. This represents a cone of approximately 5,600 ft. diameter and vertex 14 ft. below natural water level. Rainfall absorbed in this cone will be 18 million cu. ft. For the second year's pumping the vertex head is gradually depressed to 16 ft., thus bringing a larger cone into operation containing an additional 17 million cu. ft. of stored water and capable of absorbing 24 million cu. ft. In the third year the vertex head has to be still further depressed to 18 ft. in order to obtain the additional storage capacity and collection area to maintain the year's pumping. From the sixth to the tenth year the depression rate is markedly decreasing, only one foot increase taking place in this period and this suffices to keep up the supply required for each year's pumping. The extension from 22 ft. to the approximate permanent vertex head of 22.3 ft. would actually take from the tenth year till nearly the 80th year of pumping. To each of these vertex heads, the trumpet mouth head of approximately 5 ft. has to be added, thus bringing the permanent total head to approximately 27 ft. The importance of estimating the permanent depression head in tube well installations cannot be too forcibly impressed as an error in judgment or an error based on inspection of an installation during the first few years of its working may involve the construction ot a costly scheme which otherwise would not have been undertaken; or in an expenditure in practically reconstructing and refitting an installation a few years after its supposed completion. In addition to this, estimates based on incorrect vertex heads for recurring costs would soon be seriously exceeded, a subject for serious consideration when water is required for irrigation purposes.

The quality of the subsoil and its hydraulic gradient having been examined and percolation estimated from a surface and geological survey and from the valuable records maintained by the Irrigation Department, it is a simple matter to arrive at a very close approximation of the ultimate permanent head required for a given discharge.

When a lift irrigation installation consists of a battery of tubes, the necessity for correctly estimating the total depression head is of even greater importance than with single tubes, for if the head is under-estimated, not only are the initial cost and recurring costs of the scheme seriously increased, but the head being under-estimated reduces the cone of influence and tubes are thus placed much too close to one another, thereby enormously reducing the possible discharge.

Table 1 shows the conditions of depression for a tube well discharging 3 cu. ft. per second from subsoil having a limited gradient of 1 in 180. Here the cone vertex is rapidly descending for the first five years of working actually dropping 10 ft in that period. From the fifth till the eighth year there is a further drop of 2 ft., the maximum vertex head of just over 34 ft. being approximately reached after 18 years' pumping—actually reached in something like 53 years.

In this case it is obvious that the pump must be designed to give its maximum efficiency between 30 and 34 ft. and that its efficiency will be poor for the first three years of working.

In calculating the ultimate vertex head and rate of depression for any tube well average percolation is assumed. This is sufficiently accurate for all practical purposes as a year of complete drought would shorten the depression time by one year; similarly abnormal rainfall would lengthen the time in proportion as the excess was above normal.

Additional to the many advantages gained by foretelling the ultimate vertex head for a tube well, consideration must be paid to those landowners who do not possess tube wells and whose land is adjacent to tube well irrigated land. Cases have come to my notice where landowners have been deprived of their ordinary means of irrigation by the installation of tube wells on neighboring lands. When the ultimate vertex head has been calculated, then the extent of influence of the tube is at once known.

TABLE I—TIME DEPRESSION FOR 3 CU. FT. SECOND: YIELD IN SAND OF LIMITING GRADIENT 1 IN 180.

Total percolation 0.8 ft.
(Quantities in millions of cubic feet.)

Time, year	Vertex head.	Cone diam.	Total water capacity of cone.	Cone contents.	Percolation.	Available water in cone.	Water pumped.	Balance.
1st	20	7,200	81	81	32	113	94	19
2nd	22	7,900	108	(108- 81) + 19 — 46	39	85	94	—9
3rd	25	9,000	159	(169-108) — 9 = 42	50	92	94	—2
4th	28	10,080	223	(223-159) — 2 = 62	63	125	91	31
5th	30	10,080	274	(274-223) + 31 = 82	73	155	94	61
6th	30	10,080	274	(274-274) + 61 = 61	73	134	94	40
7th	30	10,080	274	40	73	113	94	19
8th	32	11,520	333	(333-274) + 19 = 78	83	142	94	48
9th	32	11,520	333	(333-333 + 18 = 48	83	131	94	37
10th	32	11,520	333	37	83	120	94	26
11th	32	11,520	333	26	83	109	94	15
12th	32	11,520	333	15	83	98	94	47
13th	33	11,800	365	(365-333) + 4 = 36	88	124	94	30
14th	33	11,800	365	(365-365) + 30 = 30	88	118	91	24
15th	33	11,800	365	24	88	112	94	18
16th	33	11,800	365	18	88	106	94	12
17th	33	11,800	365	12	88	100	94	6
18th	33	11,800	365	6	88	91	91	Nil.
19th	34	12,240	399	(339-365) = 34	93	Thirty-four additional years		

Highest pump efficiency to be from 30 to 34 feet vertex head.

For example the 3 cu. ft. per second tube shown in Table I is, together with rainfall, sufficient to irrigate roughly 1,000 acres. Assume that the owner of this tube owns 1,200 acres and the tube is centrally positioned thereon, it has an influence over a circle of 12,000 ft. diameter or say 2,680 acres and therefore water is being taken from under neighboring land extending to 1,480 acres for the benefit of only 1,200 acres; it must not be forgotten that practically this whole area will be affected in seven or eight years from the time the tube is started working.

Method of Repairing Concrete Boats.—When a concrete vessel is damaged it may be easily repaired by blocking the hole with a small timber form, inserting, if necessary, a few reinforcing bars and filling the hole with a rich (1:1:2) or (1-1) concrete. It is important to take the same precaution in packing as in continuing the placing of concrete after a cessation of work, and it is usually desirable to chip and clear the fracture so as to secure adequate adhesion of the new concrete. The patch will be able to stand water pressure in a couple of days, or even less, and if desired the form need not be removed before putting to sea again. Such a repair may even be carried out under water. The actual time required for the patch to be sufficiently strong to be regarded as an integral part of the vessel depends on its size and position, but it is usually much shorter than the time required to reach port and complete the repair of a steel vessel.—Concrete and Constructional Engineering.

Specialization by Students.—Speaking as chairman at the Crystal Palace School of Engineering on, the occasion of the award of certificates, Mr. H. E. Stilgoe, Chief Engineer of the Metropolitan Water Board, an old student of this school, told the students not to specialize. The great thing was to pay every attention to the opportunities of training as such opportunities might not come later. Men gained experience every day, but they did not get the chance of study later. If they attempted to specialize they lost a thorough grounding of all things appertaining to civil engineering.—The Surveyor.

The Attrition of Concrete Surfaces by Sea Action

By J. S. OWENS.

From a paper presented before the Concrete Institute.

We can easily realize that water alone is unlikely ever to be able to cause the wear of concrete surfaces. However big the wave which strikes them, or however rapid the current, the resulting pressure will be diffused, and will be below the limit necessary to cause fracture of the surface at any point. This is apart from solution or chemical action, and assumes sufficient structural stability to resist the general pressure. When, however, such a wave or current carries boulders, stones, or sand with it, the conditions are very different. The boulders, striking the surface with a high velocity, cause sudden intense local pressure which results in crushing to fragments the particles of aggregate on the surface. Following the blow the water thoroughly washes the injured part, removing all loose pieces and leaving everything ready for the next blow. This washing effect is very important, and differentiates the mechanism acting here from that on road surfaces; in the latter case the broken fragments remain more or less where they are, and form a pad of dust or mud which deadens the subsequent blows received. In the case of structures exposed to sea action, the surfaces are usually more or less vertical, and the process of removal of the fragments caused by blows is thus facilitated.

There is no doubt that this percussion is the prime factor in bringing about the wear of concrete surfaces. It is practically the only way in which the sea can attack a surface—i. e., by driving against it the sand or shingle carried by the water. There is not much opportunity for rubbing, although under some conditions a certain amount of this takes place. When waves are running in obliquely to the line of the foreshore, shingle or boulders carried by the waves against a wall have an alongshore component. When a stone strikes the surface of the wall obliquely there will be a certain amount of rubbing as well as percussion, as the stone will glance off against the wall. When it is remembered that the surfaces of stones which are subject to wear by wate raction are usually rough, and in the case of flints are covered with minute cracks and sometimes small cutting edges, it will be seen that this rubbing action may be somewhat akin to filing of metal with a file, and doubtless particles are thus removed from the surface.

Factors Governing Rate of Attrition.—The nature of the aggregate used for making concrete is, perhaps, the most important governing factor over which we have any control. Different stones have very different resistances to attrition. The quality of a stone which enables it to resist wear is not easy to define. It is not hardness alone, since toughness is probably of even more importance. A very hard stone, such as flint or quartz, will crack easily and come away in chips, whilst a softer and tougher stone will not suffer such deep injury from a blow.

Corners of piles, small projecting particles of aggregate and suchlike, all suffer more severely than would a flat face of concrete. This is a condition not to be entirely avoided, as, however smooth a concrete surface is to begin with, owing to the fact that it is not homogeneous, but made up of harder and softer parts, it tends to wear rough by attrition. Harder pieces of aggregate project, while the softer cementing material is worn down. Thus attrition tends to assist itself to some extent, and we have a vicious circle established. When the aggregate is tough and not liable to break easily under blows, the surface remains smoother and better able to resist wear than when a brittle aggregate is used.

The larger the size of the stones composing the beach the greater the wear due to their action when driven forward by rough seas. Concrete structures on sandy shores suffer little or no attrition, but when exposed to the grinding of coarse shingle they wear rapidly away.

Keeping in mind the fact that water alone does not wear away a concrete face, but that some hard particles, such as shingle, must be present to act as eroding agents, it is obvious that the part of the foreshore where such eroding agents are most numerous will be the part at which attrition will be most severe. The sea has a method of sorting out the materials of a foreshore into two main grades—the fine and the coarse—which we may call sand and shingle, and usually the shingle is found from mean sea level on the foreshore to above H. W. M., whereas the lower part of the foreshore near L. W. M. is usually composed of sand, unless there is no loose material available. Hence, the zone between mean sea level and H. W. M. is the zone of attrition.

It is fairly obvious that when the conditions on the foreshore are favorable to attrition then no precautions which we can adopt will prevent it. The utmost we can expect to do is to reduce the rate.

Methods of Reducing Rate of Attrition.—When the design of the work permits, it is as well to use as large particles as possible for the face work; the large particles resist blows which would fracture and destroy smaller ones. Again, we may face the concrete with a continuous face of stone blocks composed of some hard resistant material, such as granite, flint, basalt, and the like. Strictly speaking, the face is not then a concrete face, but a stone one, and for this reason does not come under our present purview.

One more important point to keep in mind is that all concrete exposed to sea action, where there is liability to attrition, should, if possible, be well seasoned before exposure. It is not, however, easy always to do this, as in the case of mass work it means keeping the forms in position for a long time, and even that is no protection if a storm comes severe enough to smash the forms, which is by no means unusual. It is best, whenever possible, to use pre-cast concrete for forming the faces exposed to attrition. In the case of piles driven into the sea bed or foreshore, they would naturally be pre-cast, and in the case of walls the part exposed to attrition is best formed with a blockwork surface; and, further, the faces of such blocks should, when possible, be formed with large stones or boulders, embedded in them. All these methods aim at improving the resistance of the surface.

Methods of Reducing the Severity of the Attack.—In the case of concrete work upon the foreshore, it is often possible to get protection for the face by groyning the immediate neighborhood, and so promoting accretion on the bed of the sea or foreshore. Such accretion shallows the water, and reduces the size of the waves before they can reach the structure.

Again, the dumping of fine shingle upon the foreshore in large quantities, where it is available, such as from dredging operations in the vicinity, has been found to be a very useful measure. This has been used with success on the foreshore between Brighton and Rottindean, the shingle being brought over in barges from Newhaven and dumped between the groynes. The sea rapidly drove this shingle up, and piled it in a bank against the face of the sea walls, covering the loose, heavy boulders and giving protection to the face, not only by actually covering part of the face of the work, but also by substituting small grain shingle for coarse boulders.

Another method which the author has been experimenting with recently—not with great success so far—has been to try and substitute for the hard, incompressible face of the concrete a softer, more elastic, face. The idea underlying this is to reduce the maximum intensity of the blows from boulders on the principle already referred to in the earlier part of this paper. The maximum stress being a function of the amount of the depression of the face before the boulder is brought to rest would obviously be reduced by increasing the compressibility of the surface. How to obtain such a surface is, however, the difficulty. The experiment has been tried of giving a coat of tar mixed with pitch and bitumen to parts of the surface of sea walls exposed to attrition, but not with great success, as the coating was not found to be sufficiently elastic, and tended to crack and fall away in pieces when struck. Also a boulder, striking such a surface, carried away, adhering to it, some of the coating. A further development of this experiment is now being tried, in which a facing of wood blocks laid with the end grain exposed is being given to the surface of the wall. Such a face would have the further advantage of being easily renewable when worn.

As it is unlikely that any of these methods will produce complete immunity from attrition, the third method of dealing with the trouble—i. e., by providing for renewing the face when worn—is probably the most efficient when it is applicable. It is not, however, always possible to do this, especially so in the case of piles and small concrete structures; but it is not so difficult when dealing with large expanses of surface such as provided by sea walls. A method developed by the author for such, and used with success on the foreshore above-mentioned, is to build in front of the wall which has suffered severely from attrition a thin secondary wall or face. This face is built up from a foundation of its own or from a ledge left on the original wall foundation for the purpose, and is about 2 ft. thick. It is found that such a face wall is not liable to be disturbed by the sea, and it can, of course, be easily renewed when worn. Such refacing walls have their surfaces formed by embedding large flints of about 4 in. diameter in the concrete behind the shuttering, and although when the shuttering is removed a smooth concrete face is shown, this soon wears away, exposing the flints, after which the rate of attrition is very much reduced.

In the case of piles which are exposed to the wearing action of shingle, it is very often the case that such wear is located within a comparatively short part of their length, and then it is possible to protect them by such means as surrounding the part at the level of the shingle or boulders causing the attrition with concrete of such dimensions that the wear does not produce any structural damage for a long time.

In this paper the author has limited the subject under consideration to wear of the surface of concrete only, and has purposely omitted to deal with damage to concrete structures resulting from stresses due to heavy blows or other causes which result in serious structural injury. The subject is one of considerable importance, although the conditions under which injury results by attrition are comparatively limited. Still it is a factor to be reckoned with seriously in designing concrete structures which have to stand on a foreshore or sea bed, where they will be subject to the grinding action of coarse shingle or boulders.

British Sanitary Engineering Developments in 1919

From The Engineer, London, Jan. 2, 1920.

Though it is more than a year now since active hostilities ceased, it cannot be said that engineering works in connection with water supply and sanitary engineering have as yet got fully into their stride again. To speak the actual truth, but little constructive work has been done. There were many reasons why it was impossible at once to resume active operations immediately the fighting was over. There was the question of labor for one thing, and then, again, there was the financial side of the matter. There are cases in which work undertaken and commenced under a given estimate, but discontinued because of the war, will cost to complete very much more than the sum originally calculated as being sufficient for the purpose. For such additional expenditure new borrowing powers are necessary, and to obtain them takes time. The same may be said of the preparation of plans and specifications for new works. Although local authorities were given permission to incur expenditure during the war period for such preparation as would enable constructional works of prime necessity to be put in hand as soon as operations again became possible, yet that permission was either overlooked or was disregarded in many instances, with the result that the works in question have not even yet been begun. Moreover, with labor in its present mood, with costs what they are, and with loans difficult to get and carrying a high rate of interest, it is hardly to be wondered at that there has been a good deal of holding back. Under the circumstances, therefore, there is not nearly so much to report as used to be the case each year in pre-war times. Yet there is work of pressing urgency which must soon be done, high prices notwithstanding, and that there is a general desire to get forward with it is evidenced by the large number of bills now before Parliament.

Insect Life on Sewage Filters.—A particularly interesting series of articles on "Insect Life on Sewage Filters" was published during the year by Municipal Engineering and the Sanitary Record. The articles, which are from the pen of Dr. W. H. Parkinson, Medical Officer of Health to the Basford Rural District Council, deal specially with the important part played by the insect known as Achorutes Viaticus in sewage purification processes, and give in detail the results of numerous investigations made in connection with it. The insect is quite small, being only about 2 mm. long, while it is calculated that some four millions of it are required to make up one pound avoirdupois. Insignificant as it is as a single unit, however, it has, when collected in mass on sewage filters and under favorable conditions, a most important effect. That it acted beneficially in conjunction with other insects and organisms in the purification of sewage was known, but its exact function had not been clearly ascertained before the publication of the articles in question, which place beyond doubt the fact that among other things the Achorutes attacks and destroys colloidal matter. It is demonstrated that of two filters which are otherwise exactly similar, and are operating under precisely the same conditions, a very great advantage is possessed by that filter which contains the Achorutes over that which does not contain them. The presence in a filter of the insect in sufficient quantities appears entirely to remove all tendency to ponding. According to Mr. H. D. Bell, who is the manager of the Stratford-upon-Avon Sewage Works, and who collaborated with Dr. Parkinson in his investigations, the clinker filter beds at his disposal works, in all of which the insect is present in enormous quantities, have not been cleaned or even touched with a rake since February, 1910, the media all the time remaining extraordinarily clean. As a consequence of the absence of a tendency to clog, filters are, of course, able to deal with larger volumes of sewage. Dr. Parkinson's inquiries have led him to the following conclusions: That the advantage attaching to a filter bed well supplied with Achorutes exists under widely different external conditions; that it is independent of the concentration of the sewage; that the insects are much more numerous in summer than in winter, and that when they are present in greatest number the beds are cleanest; and that in winter small ponding areas may form, but on the return of warmer conditions the colloidal matters are again destroyed. The reduction in the numbers of the insects in winter time had been noticed by other observers. Indeed, Mr. F. T. Hembleton, the manager of the Newcastle-under-Lyme Sewage Works, considers that a mean temperature of 40.5° F. for 10 days is necessary to bring the Achorutes again into full activity after a spell of cold. It would seem, however, that the winter, though it reduces the activity of the insects, does not, in this climate at any rate, entirely destroy them, for otherwise the Stratford beds would have had to be restoked each year, which evidently was not the case. When due precautions are taken the insect can apparently be transferred from one district to another, so that it is possible to inoculate filters which do not possess them with colonies derived from filters in which they are present in large numbers.

Contact Beds.—It is not often, nowadays, that anyone is found who will say a good word for contact beds when other methods of sewage disposal are available. The remarks made by such a distinguished authority as Mr. A. J. Martin, M. Inst. C. E., this year's President of the Association of Managers of Sewage Disposal Works, in the opening address which he delivered last month, are on that account all the more noteworthy. He was, he remarked, one of those who had maintained through good and evil report their faith in contact beds. The sweeping condemnation passed upon them was not, in his opinion, borne out by facts. It was stated that certain results could not be obtained by contact treatment. Yet those results were actually obtained. We were, he said, told that the contact bed was wrong in principle. Yet the same objection appertained to the activated sludge process. The disfavour into which the contact bed had fallen was largely due, he believed, to the failure to recognize the essential conditions under which it worked. In the case of one group of beds which he measured, only three-quarters of the effluent which went into them at their first filling was discharged, no less than 25 per cent of it being retained by the filtering material. The liquid so retained was just 15 per cent of the cubic contents of the beds, or nearly one-half of their normal working capacity, taken at 33 per cent of the whole. As time went on the amount of tank effluent dealt with at each filling diminished, while that held in the interstices of the filtering medium increased, so that when a bed had been long in use the volume of liquid permanently held up in it might be not far short of that which it received at each filling. The liquid so held up by the bed, surrounded as it was by air, was under the best conditions for purification, and the work went on uninterruptedly during the whole period that the bed was supposed to be at rest. Not only so, but the oxygen dissolved in the retained liquid and the nitrates formed in it aided materially in the purification of the next dose of tank effluent. He did not wish, he added, to claim for the contact bed more than its due, but he did claim that, given the same consideration as regarded bed material, drainage, aeration, and mode of working which was bestowed on a trickling filter, the contact bed was a valuable instrument for the purification of sewage. Where the available fall was too little for a trickling filter or where the spraying of tank effluent was likely to be objected to, a well-designed group of contact beds would often save the situation.

Sewage Treatment and By-products.—It is pretty certain that the future will witness the payment of greater attention to the treatment of sewage with a view to making the best possible use of it than has been the general rule in the past. We have, as have many others, frequently drawn attention to the waste of valuable substances which takes place when sewage sludge is destroyed, thrown away, or simply set aside. At the present time, when the necessity for making the country as nearly self-supporting as possible has been so prominently brought to public notice, it is plain to all that it is of the highest importance to develop to the full extent of our powers all sources capable of producing nitrates in a condition readily assimilable by plant life. Hitherto the efforts of the average sanitary engineer have been directed more to the conversion of putrescible sewage into innocuous substances and of the getting rid of them in the easiest way he could, than to the treatment of it in such a manner as to produce substances of commercial or agricultural value. Of course, there are noteworthy exceptions, but on the whole sewage has been, and still is, generally considered to be something noxious which has to be got rid of with the least expense and as quickly as may be. The discoveries of numerous workers have shown, however, that by suitable treatment products may be obtained from certain classes of sewage which are of considerable value. The results in the way of producing a fertilizer which have been achieved by the activated sludge process may be quoted as an example. We look upon it as most probable that in the near future it will be the aim and object of the sanitary engineer not only to treat sewage so as to render it harmless and incapable of creating a nuisance, but so as to abstract from it as much in the way of by-products as he can. Naturally all cannot have such happy financial results as places like Bradford and Morley, where, owing to the wool industry, the sewage contains much fatty matter, which, when separated and recovered, has a considerable market value, while the sludge with the fats removed is converted into a fertilizer of much enhanced value as compared with that which it possessed in its raw state. But in a large proportion of places it will, we believe, be found possible to make quite a paying business out of the special treatment of sewage with the particular idea in view of recovering by-products. The whole matter is, however, governed to a great degree by the questions of transport and the cost of the treatment, and the question in each case will have to be considered from the point of view of whether the final product will be worth transporting to the place or places where it can be beneficially employed. If the cheapest method of disposal, all things being considered, is simply to ship away the sludge and dump it in deep water at sea, then it is to be feared that such dumping will be practiced, with the consequent loss of the whole of the potential fertilizing and other valuable constituents of the sludge. We venture to think, however, that the time will come when it may be found possible so to treat the enormous volumes of sludge that are produced every day at the disposal works of, for example, London and Glasgow, as to give good financial results, while at the same time producing large quantities of good quality fertilizers as well as other valuable matters.

The Activated Sludge Process.—Despite the fact that it has had adverse conditions to contend with during practically the whole of its existence up to the present time, the activated sludge system has managed to make a wonderful amount of headway. Apart from those abroad, there is now quite a number of plants in operation in this country. Some of them may perhaps be looked upon as temporary and brought about by demands attributable to the war. Others, on the other hand, certainly have every appearance of being permanent, or at any rate of forming nuclei of permanent installations. During the past year a tank to deal with 1,000,000 gal. of sewage per day was completed at the Davyhulme sewage works of the Manchester Corporation. Manchester sewage, because it contains so much chemical and other trades waste, is decidedly strong, and the tank in question would probably be large enough to deal with as much as

2,000,000 gal. of ordinary domestic sewage. A small tank was also built at Harpenden for the Board of Agriculture and Fisheries. We understand that the object is to determine with it the actual amount of nitrogen conservable from given volumes of sewage and thoroughly to test the value of activated sludge as a fertilizer. Two other installations have been completed, and, in addition, it has been decided to treat the whole of the sewage of Reading by the activated sludge method. Reading, it may be remarked in passing, is fortunate in having two entirely separate drainage systems, one for sewage and one for rainfall and surface water. It is curious, but it is nevertheless the fact, that after-war conditions have caused more delay in the development of the process than did those existing while the war lasted. It is, furthermore, interesting to note that, though inquiries from this country have many times exceeded those from abroad, yet the orders recently received from abroad are four times as numerous as those coming from people at home.

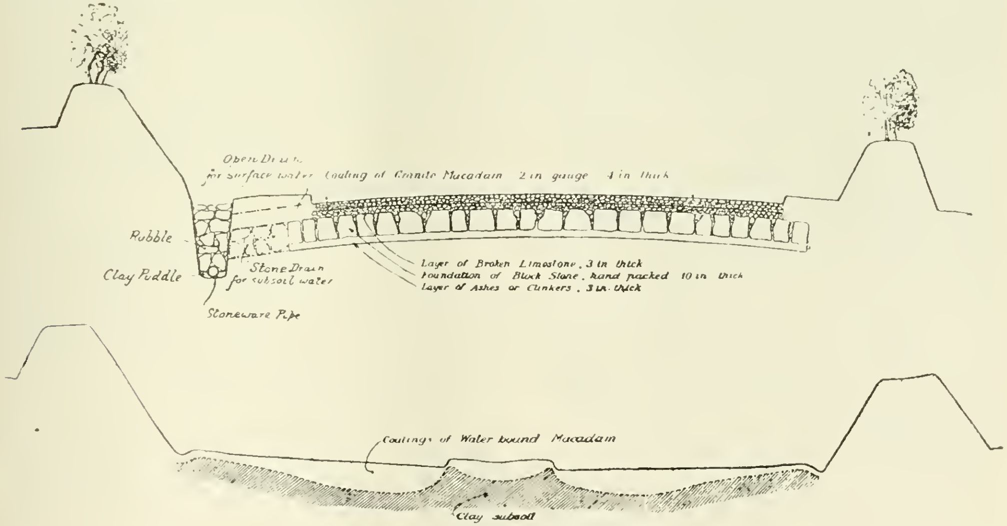
Method of Providing Drainage and Reconstructing Old Water Bound Macadam

By W. P. ROBINSON

County Surveyor, No. 2 Division of Devon, England.

From The Surveyor, London, Jan. 23, 1920.

A considerable mileage of the roads in Devonshire is on side-long ground or below the level of the adjoining land on both sides of the road, and surface and subsoil water frequently permeates into the subsoil under the carriageway, and in consequence the weight-carrying capacity of the road-bed, particularly on clay and other yielding subsoils, is seriously reduced. The writer's work of draining some roads on clay subsoils has been criticised by some with the remark that it is not practicable to drain water from clay. His reply was that his object was to prevent any more water permeating into the clay.


Open Drain
for surface water
Coating of Granite Macadam 2 in gauge 4 in thick
Rubble
Clay Puddle
Stone Drain
for subsoil water
Stoneware Pipe
Layer of Broken Limestone, 3 in thick
Foundation of Block Stone, hand packed 10 in thick
Layer of Ashes or Clinkers, 3 in thick
Coatings of Water bound Macadam
Clay subsoil

Typical Sections of Exeter and Okehampton Road, Before and After Reconstruction.

Typical sections of that portion of the Exeter to Okehampton main road, 9 miles in length, which is being reconstructed, are shown in the accompanying sketch. The subsoil is of yielding yellow clay in some portions and shale in others. The upper drawing indicates the new work and the lower the condition of the road crusts prior to reconstruction.

In 1914, when the reconstruction was commenced, this length of road was in many places waterlogged, and in consequence of inefficient drainage or entire absence of it, the clay subsoil was softened to the consistency of cream.

The intercepting drain is constructed of open-jointed second quality socketed stoneware pipes. The trench was filled in with clay puddle up to the level of the center line of the pipes with the object of preventing water finding its way to the excavated bottom of the trench, and either remaining there stagnant or flowing along the trench under the pipes. The remainder of the trench is filled with hard rubble free from small stones and dirt. Catchpits are constructed at frequent intervals, some in 9-in. brickwork and some in concrete, covered in with reinforced concrete slabs 2½ in. thick, an opening being formed in the side wall of the pits for the entrance of surface water from the carriageway.

Having in view the importance of not only intercepting water from the higher ground but of draining the road-bed, the old road crust was removed to allow of the new road-bed being formed to a camber of not less than ½ in. to a foot, and this camber was extended outside the width of the new carriageway to meet the intercepting drain-trench on the higher side of the road, and on the lower side frequent trenches were cut and filled with rubble below the level of the new road-bed and leading therefrom through the fence to suitable outlets. In some places it was deemed advisable to construct in addition subsoil drains in the new road-bed, these being laid herringbone fashion leading to the main intercepting drain and consisting of trenches filled with rubble or facines. With the object of preventing the cross-fall of the new road-bed being pressed by subsequent rolling out of its proper shape and the consequent interference with the efficient drainage of the road-bed, fascines and loppings of fir trees were laid in the clinker and the clay subsoil removed to a greater depth adjoining the drain trench. This work has been described in detail with the object of advocating the policy of "prevention is better than cure." Had this length of road been efficiently drained prior to 1914 probably a considerable portion of the cost of reconstruction of the foundations and reforming of the road-bed might have been avoided.

The utmost attention should be given to the proper drainage of the road-bed or subsoil on which a new subcrust is to be laid; also to the complete filling of the voids in new subcrusts of water-bound rubble, stone or brick.

The Telford system of laying rubble or stone foundations, if efficiently carried out, reduces the voids as compared with the macadam system. In either case the voids should be completely filled with limestone chippings containing not less than 50 per cent of fine dust or other suitable binding material, mixed with water to form a slurry, and brushed into the voids with the object of rendering the subcrust as watertight as possible. When practicable it is also an advantage to expose a new water-bound subcrust to the traffic for some time before applying the surface crust, so that any weak places which may become apparent under the strain of traffic may be strengthened or levels adjusted before applying the surface crust. During the reconstruction of the Exeter to Okehampton main road previously referred to the new subcrust was left exposed for not less than six months—in fact, some portions laid in 1914-15 are only now being coated with the surface crust. In this case the stability of the new subcrust has been ensured.

Lateral Support is absolutely necessary for all forms of construction to carry heavy traffic without movement of the surface or subcrusts. In the sketch the subcrust is shown extended outside the edges of the new surface crust with the object of giving lateral support, the flat-bedded stones being laid longitudinally like curb for two courses instead of transversely, as under the surface crust. On soft clay subsoils the writer has experienced movement of the earthen abutments of a water-bound surface crust at a distance of 3 ft. from the wheel of the steam-roller, and the latertal pressure was sufficient at that distance to crack the 9-in. brick wall of a catchpit.

Precise Leveling in England

By Maj. Ernst Olaf Henrici.

Abstract of paper read before the Institution of Civil Engineers.

When the heights of the original bench marks of the Ordnance Survey were first determined, it was considered that the work done would stand good for an indefinite period, and that all that would be required on revision would be to replace such bench marks as had disappeared, except in the mining districts where it was known that subsidences were liable to occur. Experience has shown, however, that many of the marks have altered their heights to a greater or less extent, either from subsidence of the structures on which they had been cut, or by actual displacement. Also a considerable number of marks have disappeared. It is consequently becoming increasingly difficult to distribute the inevitable errors of the secondary leveling, and to prevent their accumulation.

It was decided in 1911 to undertake the leveling of an entirely new network, to form the basis for the heights shown on the maps, and at the same time to study more thoroughly the height of mean sea level. There seems to have been very little advance in the practice of spirit leveling in this country for many years, and in consequence a study of progress made in other countries was carried out, and levels of various patterns were experimented with before the methods adopted were selected.

The new lines are laid out so that it is possible to erect at intervals of about 25 miles special "fundamental" bench marks. These marks are confined to sites where the presence of rock within reasonable distance from the surface makes it possible for the mark to be either fixed in the living rock, or in concrete founded on the rock. Sites are avoided where the marks are likely to be disturbed by mining or quarrying. These marks have three reference points, one consisting of a metal bolt let into the top of a granite pillar, for general use, and two lower marks which are buried, and are for the use of the survey only, for the purpose of checking the height of the upper mark in time to come. Intermediate marks are of a special form of gun metal plate let into the surface of walls. The "probable error" of the difference in height between any two consecutive "fundamental" marks is about 0.01 ft., i.e., it is an even chance whether the actual error is greater or less than this amount, and it is very improbable that the error will be as much as three times this amount.

The intermediate marks cannot be relied on to hold their height to the same extent as the fundamental marks, as it is impossible to avoid passing over ground that is liable to subsidence due to mining operations, or to movements such as are caused by the varying moisture content of the soil in alluvial or fen districts, or to avoid the possibility of direct subsidence of the structures on which the marks are placed.

The chief conclusions arrived at are: (1) The design of the standard leveling instruments as used in this country for many years can be considerably improved, not only for precise work, but for all work. The instrument used in the work, discussed in the paper, is one designed by Dr. Wild (formerly of the Swiss Survey), and made by Messrs. Zeiss, of Jena. The author is glad to say that firms in this country are now producing instruments embodying the good points of the Zeiss instrument. (2) The chief cause of error in the leveling as now carried out is due to the movements of the supports of the leveling staves during the time they are "holding the height" between the forward and back readings to the staff.

Recent Advances in the Utilization of Water Power

By E. M. BERGSTROM,

From The Electrician, London, Feb. 6, 1920; abstract of a paper read before the Institution of Mechanical Engineers.

The extended field given to water-power development by the application of electricity on a commercial basis, created a demand for a high-speed turbine working under low heads, and to meet this new condition American engineers turned their attention to the Francis turbine, invented in 1849, and produced a high-speed type of runner known as the "American Type." As in allustration of the rapid extension of the use of the Francis turbine, the manufacturing records (Table I) of an eminent European firm of turbine-makers show the increase in output per turbine, and indicate the modern tendency of installing less units but of larger capacity.

TABLE I.

Period.	Jenval No.	Girard No.	Francis No.	Tangential wheels No.	Total B.H.P.	B.H.P. per Turbine.
1850-1891 ...	904	883	7	623	179,256	74.2
1895-1899 ...	72	99	98	232	114,818	229.1
1900-1904 ...	8	16	464	300	390,252	495.1
1905-1909 ...	...	...	457	336	886,582	1,118.0
1910-1914 ...	...	...	375	219	1,162,380	1,956.8

This last-mentioned feature of modern hydro-electric development is evident from figures recently published by an American manufacturer, who commenced the manufacture of the Francis turbine in 1895, and since that date has completed installations with an aggregate output of 1,683,720 b.h.p. corresponding to an average output of 8,000 b.h.p. per turbine delivered. Table II shows the most representative high-pressure turbine installations installed during the last 15 years.

According to broad principles, the turbines are classified in two categories, namely, reaction and impulse turbines. The Francis turbine belongs to the former, and the high-pressure impulse turbine—or more familiarly known as "Pelton wheel"—belongs to the latter category. These are the only types now employed in modern water-power development.

Francis Turbines.—The fact that the standardization of the Francis turbine was not founded on a strictly theoretical basis militated for a long time against improvements in its design and manufacture for conditions of large hydro-electric developments. Most of the leading manufacturers have now adopted the manufacture of standard runners, each series corresponding to a certain specific speed and selected to meet the conditions most frequently met with. Testing plants which have proved so valuable in the development of the design of runners are now installed in the works of most European turbine manufacturers, although in America most tests are carried out at the famous testing plant at Holyoke. Not only are standard runners accurately analyzed on these testing plants, but all new special designs are subjected to test, and in the case of turbines, whose large capacities do not permit of testing, accurate geometrically similar models of small diameter are made for testing purposes, and the results represent very accurately the performance of the master runner.

Early attention was paid to increasing the unit speed of runners, the value of which became more apparent with the introduction of direct turbine-driven generators. Considerable study, both theoretical and experimental, has been devoted to this subject, and all attempts at improvements in design of runners during recent years have been in the direction of increasing the maximum value of the specific speed so as to secure a larger output under a given head and speed, or conversely to obtain the highest possible speed for a given head and capacity. The development of the high-capacity runner has had a far-reaching effect on the economical arrangement of units for low-head plants, in addition to obviating many inherent disadvantages in the arrangement of two or more runners on a common shaft, a practice which was adopted to secure a high speed in order to effect a reduction in the initial cost of directly driven generators.

Another significant fact to be recorded is the long range of gate openings for which an efficiency of over 80 per cent is obtained. In this connection it is interesting to recall that only a few years ago Dr. Prazil, in the course of a paper on Turbine Efficiencies, predicted that much further advance in the future could not be expected in regard to efficiencies. The average efficiency of the tests then published was 85 per cent. which value has been greatly exceeded, and a general increase of 10 per cent above efficiencies obtained about 12 years ago can now be recorded. The efficiency, in itself a valuable asset, is, however, not the all-important feature of modern turbine developments; the improvement in mechanical details and construction and simplicity in design, together with higher standard of workmanship, are all important factors which have contributed to the advances in the utilization of water-power, by insuring freedom from breakdowns, continuity of operation, simplicity in working and accessibility to effect repairs, all of which are of vital importance in connection with any power development.

The most notable developments in hydro-electric power plants which have taken place in recent years have been stimulated by the development of the "high capacity" runner. This latter construction has permitted the adoption of the single vertical turbine, which possesses many economic advantages over the arrangement of the multiple runner, either on vertical or horizontal shaft, and has facilitated the promotion of the large-power low-head hydro-electric undertakings which, during the last six years, have shown such a remarkable development in the United States of America.

A unique installation of the medium-pressure type turbine is the Porjus Power Station, Sweden. This plant is situated underground, but the turbines are enclosed in steel casings and placed at the bottom of the intake-shafts about 160 ft. below ground level. The vertical shafts are cut through solid rock and provided with liners of steel pipes with an internal diameter of 11 ft. 6 in., and with flanged connection to the turbine-casing. There are five units with an average capacity of 12,500 HP. each under a net fall of 163 ft., running at 225 r.p.m. The turbines are of the double type with two runners, discharging into the common suction-casing. The power-house is also blasted out of solid rock, and is 36 ft wide and 310 ft. long, communicating with the turbine chambers through the short tunnels which accommodate the shaft extension connecting turbines and alternators. The roof is supported on a strong concrete arch, and by the provision of false walls and roofs leaving a space between the rock and the walls through which warm exhaust air from the generator is allowed to pass, all damp is prevented from penetrating into the power-house. The generators have a normal output of 11,000 k.v.a at 10,000 to 11,000 volts. The necessary switchgear and transformers are also in this case placed in a separate building on ground level, a shaft providing communication between this building and the power-house below, through which the heavy parts of the machinery can be lowered, in addition to which, there is lift accommodation both for passengers and goods. The line voltage is 80,000, the power being utilized for railway traction and for mining purposes.

High-Pressure Francis Turbines. Much attention has of late been focused on the development of low and medium Francis turbines, but nevertheless the high-pressure Francis turbine has shared in the remarkable and rapid development and improvement in design of the hydraulic turbine. The most notable feature is its adoption for a very much higher head than ever contemplated until a few years ago, so that, under certain conditions, it rivals the Pelton Wheel. The reason for this is the modern tendency of larger capacity per unit, coupled with maximum permissible speed to reduce the cost of the electric generators. As a result, the design of the Francis turbine has been modified and improved to answer the additional requirements of water turbines working under high pressure, and has now been employed under heads of approximately 745 ft.

Speed Regulation.—The development of the design and construction of governors has naturally been closely bound up with the general advances in the design of Francis turbines. In fact, it may be stated without exaggeration that the progress in the application of water-turbines is to a great extent due to the satisfactory solution of the governor problem as the provision of a quick acting and reliable speed-controlling device forms one of the most important features of hydro-electric development. The old type of mechanical governor proved totally inadequate for the needs of efficient speed-control in connection with hydraulically-driven generators. As a consequence the hydraulic type of governor was evolved, which in the first place was actuated by the water pressure, but later, however, was substituted by oil pressure in order to eliminate several bad features of the water-pressure governor; that is, sticking due to gritty water, and liability to corrosion of the various mechanical parts. The automatic oil-pressure type of governor has been steadily improved, and has now reached a high state of perfection, possessing all the qualities required by modern practice for effective and reliable speed-control.

For large turbine units the servo-motor is built together with the turbine, and in the case of several units, are all supplied from a central oil-supply system. In the case of enclosed turbines supplied through pipe-lines, the closing time of the governor and guide-vanes respectively must be adjusted correspondingly longer than in the case of open-type turbines in order to avoid dangerous pressure rises in the pipe-line, owing to the change of momentum of the flowing mass of water, in addition to providing a heavy fly-wheel to keep the speed variation within permissible limits. This arrangement is only possible where the pipe-line is comparatively short, and cannot be adopted for high-pressure turbines where the hydraulic conditions imposed by high head and long pipe-lines render the governing problem far more difficult. In such cases the governor is operated in conjunction with a pressure-regulator or relief-valve, in such a manner that when the governor closes the guide-vanes of the turbine the relief-valve opens, discharging the water into the tail-race, so that the same amount of water is flowing through the pipe-line, thus avoiding any change in the momentum, and consequently no pressure rise can occur.

In this type of pressure-regulator the governor furnishes the necessary power to operate the valve. This type of valve could not be used with advantage in many plants, as a very large capacity governor would be required to operate the valve. The modern type of pressure-regulator for Francis turbines has therefore been designed in such a manner that the governor only operates a small relay valve, the water-pressure in the pipe-line being utilized to operate the valve, and thus obviate the additional power being imposed on the governor.

Surge Tanks.—A further point which must be subject to particular consideration is the fact that in many medium-pressure plants the pipe-line is often of considerable length as compared with the total head, so that in case of a sudden demand for an increase of flow following a sudden increase of the load on the turbine, the water in the pipe-line cannot accelerate at such rate as required by good governing. It is apparent that the pressure-regulator cannot, in this respect, be of any assistance, and under these conditions a standpipe or surge-tank must be provided. In the

TABLE II.—REPRESENTATIVE HIGH PRESSURE TURBINE INSTALLATIONS.

Plant.	Country.	Year of installation.	Net head in feet.	Output per unit in B.H.P.	Number of units.	Speed in R.P.M.	Type.
The Mexican Light & Power Co., Necaxa....	Mexico	1903	1,279	8,200	6	300	4-jet vertical.
Brusio Hydro-Electric Plant	Switzerland	1905	1,350	3,500	12	375	Single-jet horizontal.
Rio de Janiero Tramway, Light & Power Co.	Brazil	1906	950	9,000	6	300	4-jet vertical.
British Aluminium Co., Ltd., Kinlochleven..	Great Britain	1907	900	3,300	11	300	Double-jet horizontal.
Tysse Hydro-Electric Plant	Norway	1907	1,269	4,800	7	375	Single-jet horizontal.
Rjukanfos Hydro-Electric Plant, Station I..	Norway	1908	930	14,450	10	250	4-jet twin runner horizontal.
Loentch Hydro-Electric Plant	Switzerland	1908	1,075	6,000	4	375	Double-jet overhanging horiz.
The Mexican Light & Power Co., Extension.	Mexico	1909	1,279	16,000	2	300	4-jet vertical.
Biashina Hydro-Electric Plant	Switzerland	1909	850	11,000	3	300	4-jet vertical.
South California Edison Co., Kern River, Plant I..................................	U. S. A.	1910	865	10,750	4	250	2-jet twin runner overhanging horiz.
Lake Buntzen Hydro-Electric Plant, Station II.............................	Canada	1912	395	13,500	3	200	8-jets quadruple runner horizontal.
Kinugawa Hydro-Electric Plant	Japan	1912	1,050	6,000	6	375	Single-jet horizontal.
Rio de Janiero Tramway, Light & Power Co. Extension	Brazil	1912	950	20,000	2	300	4-jets vertical.
Loentch Hydro-Electric Plant Extension ...	Switzerland	1913	1,150	16,000	1	300	Double-jet overhanging horiz.
Tata Hydro-Electric Plant, Bombay	India	1914	1,650	13,500	6	300	Single-jet horizontal.
Rjukanfos Hydro-Electric Plant, Station II..	Norway	1914	830	16,400	10	250	4-jet twin runner horizontal.
Aura Hydro-Electric Plant	Norway	1916	2,350	23,500	6	250	Single-jet horizontal.

event of a sudden throwing off of the load on the turbine, the water would rise in this tank and absorb the energy given out by the flowing water column when changing its momentum during the retardation of the flow and corresponding to the new load conditions. On the other hand, in the event of a sudden demand for more power, the stored water in the surge-tank would instantaneously supply the additional quantity of water required until the water column in the upper portion of the pipe-line has had time to accelerate, and consequently the level in the tank would be lowered. The area of the tank must be so dimensioned that the amplitudes of the water-waves or oscillations are as small as possible and steadily diminish until the quiescent water-level is reached, in order not to influence adversely the conditions for stable governing.

Pelton Wheels.—The chief characteristic of the impulse wheel is the long range of load during which the efficiency is constant. The same tendency to adopt a uniform design is also noticeable in respect of the nozzle where the various designs of rectangular nozzle with movable lip have been discarded in favor of the circular nozzle with concentric pear-shaped spear or interceptor movable in axial direction for regulating the quantity of water which is employed in modern Pelton wheel design. The most important improvement, however, is in respect of the system of regulation, which, as in the case of the Francis turbine, had to be adapted for the new conditions of electrical transmission, and at the same time conform to the increased demand for accurate and reliable automatic governing. Three distinct systems of automatic governing are now employed, namely: (a) by-pass valve regulation; (b) regulation with deflecting nozzle; (c) combined spear and deflector regulation. The object aimed at in each of these methods of automatic control is to obtain an instantaneous regulation of the quantity of water in response to any load changes, at the same time insuring a slow and gradual retardation of the flow in the pipe-line to obviate any dangerous increase in pressure.

Summary of Recent Features of Hydro-Electric Development.—The outstanding features in the development of the utilization of water-power can be summarized as follows:

1. The exclusive use of two types of turbines only, namely, Francis re-action turbines for low and medium heads, and Pelton impulse wheels for high heads.
2. The extension of the use of Francis turbines under heads approaching 800 ft., and Pelton wheels in single stage up to 5,500 ft.
3. The exclusive adoption of balanced wicket-gates for regulation of Francis turbines and the circular nozzle with combined deflector and needle regulation for Pelton wheels.
4. The standardization of turbine runners and increased specific speed permitting the use of single vertical units of large output under low heads.
5. The general increase of output per unit, the maximum output at present being 31,200 b.h.p.
6. The general increase of the overall efficiency of about 6 to 10 per cent.
7. The exclusive use of oil-pressure governors.
8. The efficient regulation (by means of differential surge-tanks) of turbines using long pipe-lines.
9. The employment of large diameter pipe-lines under high heads resulting in an appreciable reduction of the initial cost of development.

These developments, coupled with the improved construction of impounding dams in addition to multifarious improvements in details to ensure effective safeguards and reliability in operation, constitute an enormous advance from a purely technical point of view.

Cost of Building Material in England.—The increased cost of building material since 1914 was shown in a table submitted on Feb. 16 by the Director of Housing to the Housing and Town Planning Committee of Edinburgh Town Council. In July, 1914, common bricks cost 27s. per 1,000, in October, 1918, 55s., and in January of this year 82s. 6d. per 1,000. Timber had increased in price from 1s. 6d. to 2s. 6d. per cubic foot in 1914 to 10s. 6d. in January this year. Slate had risen from 57s. 6d. per ton to 150s. per ton, tiles from 60s. to 137s. 6d. per 1,000, lead tube from 22s. 6d. each to 78s. 6d. each, and sash-weights had advanced from 5s. 6d. to 23s. per cwt.—The Surveyor.

A Union of Technical Engineers

From Engineering and Industrial Management, London, Dec. 18, 1919.

Several hundred engineers and engineering students, representing many branches of the profession, attended a mass meeting of the Society of Technical Engineers (South-Eastern District), which was held in London recently, under the chairmanship of Dr. J. F. Crowley. Mr. C. H. Wordingham, formerly president of the Institution of Electrical Engineers, was the principal speaker. The society, which was formed last year, is now registered as a trade union for the protection of engineers in the technical, managerial and administrative grades whose interests may be threatened in industrial disputes. Its membership is open to qualified men not engaged in purely manual work, but does not exclude men who do not possess degrees in engineering or pupils who are in course of training. During the past year the society's membership has steadily expanded, branches have been formed in many towns, and members are now being grouped into sections according to the branch of engineering in which they practice.

Dr. Crowley, in announcing that the society has been registered as a trade union pointed out that technical engineers were at last in a position of equal advantage with federations of employers and unions of manual workers. He briefly outlined the aims and objects of the society as stated in the rules, and welcomed the large number of students present, who would be eligible for junior membership.

Mr. C. H. Wordingham explained that he was not a member of the society, and, as an employer, was not even eligible for membership; he had had nothing to do with the formation of the society. During his two years' presidency of the Institution of Electrical Engineers, however, he had taken a very keen interest in the provision of a suitable organization for the members of that institution. Speaking solely as an individual, and not as the representative of any professional body, he said he believed that at heart the British race were essentially individualistic, and that we had won our position by individual action. There was, however, at the present time a very strong movement in favor of joint action, and this movement was strengthened by the refusal of the Government to deal with individuals on matters affecting the relations of employer and employe. The Whitley Councils recognized only two parties in industry; the employer and the manual worker. There was, however, in the engineering industry another very important class, whose interests were not necessarily coincident with either, namely, the technically-trained engineer. It was the aim of the society to include all such engineers in its membership. An important object of such a union was to enable force to be employed if this should ever prove necessary. Many, probably most, would very much rather go through the world getting what was due to them on a logical basis, without having to use force. Force was regrettable, but it was sometimes necessary. The technical engineers—that is to say, properly-trained engineers—found themselves left entirely out of consideration on the formation of the Whitley Councils. They could not go on the side of the employer, and most of them would not go on the side of the manual worker, but they felt that they ought to have recognition. The only way to get recognition was to have strength, which meant getting the greatest possible number of members having the necessary qualifications. The existing engineering institutions were quite useless for securing the objects of the society, but had their own field in the discussion of technical matters. They were not concerned with the material interests of their members, and it was essential that some other body should supplement their activities in this direction. It was a matter of fundamental importance to find the best way to combine all classes of engineers into one association. He understood that the society had adopted a kind of duplex arrangement; that is to say, the society was divided geographically into districts and branches, and also on an occupational basis depending on the class of work performed. This double arrangement was most important, and would facilitate co-operation with the professional institutions. The Institution of Civil Engineers had a bill before parliament now for the registration for all those desiring to practice as civil engineers. There was, however, some difficulty in framing an accurate definition of an engineer. The working rule regulating the admission of members to the society was probably of value in this connection. The society would add greatly to its prestige if it could carry with it the great professional institutions. It was very necessary for the society to keep to its proper sphere as a protective association. Another important point was to get into the society every engineer, right up to the highest, because although numbers did count, the standing in the profession of those who were members would count quite as much. He warned the society against any ill-considered action, especially in the early stages of its career. He thought it could safely be assumed that, having a general body of sensible men, a very great deal might be done by the society to uphold the dignity of the profession.

Dr. Crowley laid stress on the fact that the Whitley Councils only recognize two classes; employers and the trade unions. In their efforts towards combination trade unions of manual workers had endeavored, in some cases by means of strike threats, to force staff men to join them. On this account alone it was necessary for engineers to have their own trade union. The present-day tendency towards nationalization was also a very important reason for the existence of the society. Dr. Crowley emphasized that the question of legislation was of vital interest to the technical engineer, for both employers and manual workers had their representatives in Parliament. He quoted figures in support of his statement that the growth of British electrical industry has been seriously retarded by ill-considered legislation in the past. Before the idea of this society was even conceived, Mr. Wordingham had been devoting himself to finding the best means of forming such a society as theirs, and this was clear proof that the society was proceeding on the right lines. The constitution was now completed, and was ready for circulation to members. It might appear that a great deal of time had been taken in getting out the constitution, but it was highly probable that this constitution, combining the two forms of representation which had hitherto been regarded as antagonistic, would be accepted as a model in the formation of bodies of a similar type.

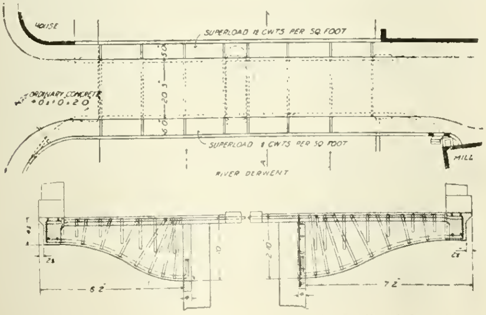
Widening of Road Bridges by Ferro-Concrete Cantilever Sidewalks

From The Surveyor, London, Jan. 16, 1920.

The addition of ferro-concrete cantilever footpaths was the means adopted to widen by 11 ft. a bridge over the river Derwent, in the village of Milford, near Derby, the Mouchel-Hennebique system of construction being employed in the carrying out of the work.

The original structure had a total width of only 18 ft. between parapets, and the approaches were anything but well arranged, probably to some extent because of the proximity of buildings to the ends of the bridge. The buildings in question were fortunately at distances permitting the bridge to be widened 6 ft. at the upstream side and 5 ft. at the downstream side, without involving the destruction of property, and at the same time allowing the approaches to be improved, particularly at the left-hand end of the bridge.

As a result of the extension, the width of the bridge has been increased from 22 ft. 6 in. to 33 ft. 6 in.—practically 50 per cent. Details of the cantilever construction are given in Figure 2, these members being typical of the cantilevers for the downstream and upstream footpaths respectfully. In place of a roadway 18 ft. wide, without any proper facilities for foot passengers, the bridge now has a roadway of 20 ft. 3 in., and two footpaths 5 ft. and 6 ft. wide respectively, as represented in the plan. It will be noticed that at the left-hand the downstream footpath is curved around the house and adjoining the new parapet, and that the approach of the upstream side has been considerably improved by a continuation of the ferro-concrete cantilever construction.



Figs. 1 and 2—Plan of Bridge as Widened and Details of Cantilevers.

Figure 3 is a cross section giving a general idea of the manner in which the cantilevers were applied to the existing masonry work. The original appearance of the structure has been very little changed, as the former parapets have been reinstated in their new position. In fact, unless the work is inspected at close quarters, there is little or no evidence of any alteration, the increased width of the roadway and the addition of the footpaths being the most striking features.

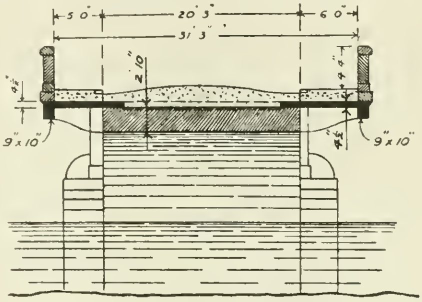


Fig. 3—Cross Section of Bridge as Widened.

Figure 4 is a half plan of the bridge showing the arrangement of the cantilevers at the left-hand approach and river span. Each cantilever consists of a semi-beam 2 ft. 10 in. deep at the fixed end and 1 ft. 2 in. deep at the free end by 6 in. broad. At the fixed end each cantilever is finished by a template measuring 2 ft. 11 in. by 1 ft. 3 in., and at the free end each cantilever is in monolithic connection with a longitudinal beam, 1 ft. 3 in. deep by 9 in. broad, supporting the parapet on either side of the bridge. The templates are bedded into recesses cut in the old masonry as represented in Figure 2, and the cantilevers of each pair are connected by a tie-rod embedded in concrete and passing from side to side of the bridge. Therefore the weight of each cantilever acts as a counterpoise to the cantilever on the opposite side of the structure. The cantilevers on the upstream and downstream sides respectively are joined together by a continuous slab, 4½ in. thick, projecting 1 ft. 6 in. beyond the templates, this slab acting as a flange common to the whole series of cantilevers, as well as to the parapet beams. The general arrangement of the reinforcement is indicated in the section, and it will be understood that the efficient disposition of the steel bars and stirrups, combined with the great strength of the monolithic concrete, afford an adequate guarantee of ample resistance and rigidity.

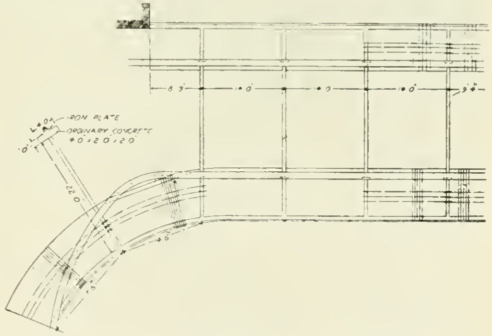


Fig. 4—Half Plan of Bridge Showing Arrangement of Cantilevers.

The cantilever footpaths were calculated for a superload of 168 lb. per square foot, and when officially tested under 50 per cent in excess of this load the deflections registered were quite inappreciable.

The widening was carried out under the superintendence of Mr. J. W. Horton, Assoc. M. Inst. C. E., the county surveyor of Derbyshire, in accordance with the working drawings of Messrs. L. G. Mouchel & Partners, Limited, of Westminster.

Sewage Purification Problens

By ARTHUR J. MARTIN.

Abstract of inaugural address as President of the Association of Managers of Sewage Disposal Works.

The successful purification of sewage is not merely a matter of selecting a process. It depends hardly less on the care with which the details are worked out. There are certain points in current practice which seem to deserve more consideration than they have yet received. Why, for instance, in the case of continuous flow sedimentation, is it considered necessary to retain the sewage in the tanks for a given number of hours? If septic action is aimed at, time must, of course, be allowed for the organisms to do their work, and in the case of a sewage subject to violent changes in composition or strength the tanks should be large enough to yield an effluent approximately uniform in quality. But where the sole object of tank treatment is to separate the solids from the liquid, and it is desired to filter the latter in a fresh condition, would it not be better to make the tanks as small as possible and to rely rather on correctness of form than on a prolonged detention of the sewage in them for the attainment of the object in view?

Design and Operation of Tanks.—Why, then, are tanks—and grit chambers—so generally made rectangular? This form of tank is easy to design and to build, and for quiescent settlement doubtless it serves as well as another, but for continuous flow it is surely as ineffective a shape as could well be devised. A circular tank, in which the sewage enters at the center and flows in every direction to the circumference, affords the best conditions for the speedy settlement of the solids, but circular tanks do not fit well together. I pointed out, in a paper on "Tanks," read at the annual general meeting in 1912, that a wedge-shaped tank, having its inlet at the pointed end, and its outlet at the wide end, gives precisely the same conditions as the circular tank.

More pains might with advantage be taken to free a tank effluent from suspended matter before filtration. In a septic tank the partially digested sludge accumulates at the outlet end, and as decomposition proceeds gives off a great deal of gas, which breaks up the deposit and brings large quantities of it to the surface, where it is carried off with the effluent. This fouling of the effluent would not occur if outlets for sludge were provided at the outlet end of the tank and regularly used, but, following precipitation tank practice, one frequently finds the sludge valves placed at the inlet end.

The emission of suspended matter from the tanks would matter less if opportunity were afforded for its deposition on the way to the filters. It readily settles, but is periodically distributed by fresh evolutions of gas. It should therefore be side-tracked clear of the effluent channel, which can easily be done by means of a circulation induced by the flow. Too frequently, however, the effluent channels are so formed as to carry on to the filters practically the whole of the suspended matter which comes from the tanks.

Contact Beds.—It has always seemed to me that the sweeping condemnation which was so generally passed upon the contact bed was not supported by facts. It was, for instance, argued with great plausibility that certain results could not be obtained by means of contact filtration, but it was hard to accept this conclusion in view of the fact that such results were actually attained. Again, we were told insistently that the contact bed was "wrong in principle."

But the same criticism applies with equal force and on precisely the same ground to that newest mode of treatment to which many of us look so hopefully today—the activated sludge process. For in both we have the same essential conditions—a tank containing sewage in intimate contact with a myriad of activated particles—in the one case of clinker, in the other of sludge—in the presence of oxygen. The two processes have this further point in common—that if the supply of oxygen is cut off, the working of the process is impaired. In such a case the contact bed probably suffers less, the reserve of nitric oxygen which the liquid contains enabling it to continue its work in the absence of the free gas.

The disfavor into which the contact bed has fallen in many quarters is largely due, I believe, to the failure to recognize the essential conditions under which it works. It has been very generally assumed that the work of a contact bed is done wholly or in great part while the bed is resting full, to the neglect of the longer and more important period of draining and aëration. It seems to have been overlooked that, although during this latter period the bed is nominally "empty," it actually contains in its interstices a very considerable volume of liquid. In the case of one group of beds which I measured, only three-quarters of the effluent which went into them at their first filling was discharged, no less than 25 per cent of it being retained by the filtering material. The liquid so retained was just 15 per cent of the cubic contents of the beds, or nearly one-half of their normal working capacity, taken at 33 per cent of the whole. As time goes on, the amount of tank effluent dealt with at each filling diminishes, while that held in the interstices of the filtering medium increases, so that when a bed has been long in use the volume of liquid permanently held up in it may be not far short of that which it receives at each filling. The liquid so held up by the bed, surrounded as it is by air, is under the best conditions for purification, and the work goes on uninterruptedly during the whole period that the bed is supposed to be at rest. Not only so, but the oxygen dissolved in the retained liquid and the nitrates formed in it aid materially in the purification of the next dose of tank effluent.

The great practical advantage of the contact bed lies in the exact apportionment of the work which it affects over the whole body of the filtering medium, thus solving automatically and completely that problem of distribution upon which so much ingenuity has been expended in the case of the trickling filter. I have no wish to disparage the trickling filter—I have used it myself in many works—but I feel very strongly that the contact bed has not, as a rule, been fairly treated.

Think for a moment of the care which is bestowed on the selection and grading of the material for a trickling filter, on its drainage and aëration, and the method of feeding it, and then of the manner in which contact beds have been, as a rule, constructed and worked. If you bear these things in mind you will, I think, agree with me that many of the comparisons which have been drawn between the two modes of filtration have been anything but fair.

Slow vs. Quick Filling of Contact Beds.—The method of working contact beds appears to me to deserve more attention than it has generally received. The old empirical cycle —two hours filling, two hours resting full, two hours discharging, and two hours aërating—has too often been slavishly followed without regard to the essential needs of the bed. In this cycle the lower layers of the material are waterlogged for periods ranging up to six hours, the most important stage of all, that of aëration, being cut down to a minimum. With the gradual filling adopted, the least use has been made of the air entrained in the interstices of the bed, while the slow discharge has favored the retention of the particles of suspended matter, which the trickling filter, on the other hand, is expressly encouraged to disgorge.

A consideration of these points has led me to adopt a working cycle better suited to the work to be done. The filling has been hastened so as to secure a more thorough admixture of the incoming liquid with the air in the bed; the period of contact has been shortened, and the discharge accelerated, the time saved from these three stages being added to the important period of draining and aëration. The "quick-filling" automatic gear which was designed to work on these lines was first used for a group of six fair-sized experimental beds laid down by the corporation of Leeds at their Knostrop works. The results obtained have fully justified the innovation in the method of working, the percentage purification effected by the beds on the tank effluent during the last half-year, for which I have records averaging 72 per cent in albuminoid ammonia and 87 per cent in oxygen absorbed.

It is often claimed for trickling filters that the amount of tank effluent dealt with by a given volume of filtering medium employed in this way is much greater than with contact beds. The actual figures at Leeds during the period in question were 94 gal. per cubic yard per day for the trickling filters and 88.8 gal. for the contact beds—not occasional storm flows, be it noted, but ordinary everyday working.

I do not wish to claim for the contact bed more than its due, but I do claim that, given the same consideration as regards bed material, drainage, aëration, and mode of working which is bestowed on a trickling filter, the contact bed is a valuable instrument for the purification of sewage. Where the available fall is too little for a trickling filter, or where the spraying of tank effluent is likely to be objected to, a well-designed group of contact beds will often save the situation.

The Activated Sludge Process.—The activated sludge process is the most promising novelty for the purification of sewage which we have had for many a long year. The idea of purifying sewage by blowing air through it was not new. It was put forward many years ago by Colonel Waring in America, and by Mr. Lowcock in this country. But nothing came of it at the time. The direct oxidation of sewage is far too long an operation to be effected within the brief period during which the air remains in contact with the liquid. The distinguishing feature of the new process was the introduction of any army of organisms capable of seizing on the air on its way through the sewage and by their life operations bringing about the changes which direct oxidation was powerless to effect.

The drawback of the process, as at first carried on, was the cost of compressing the large volumes of air which were then found to be necessary. Even with the improved methods in use at St. Albans and Worcester, the amount of air used is respectively twenty-two times and sixty-seven times that required for oxidation purposes. It is claimed that the excess of air serves to agitate the sewage and keep the activated sludge distributed through the liquid. This it undoubtedly does; but compressed air is a very expensive agent to employ on this purely mechanical work. At Sheffield and elsewhere revolving paddles have been used for the purpose, with, I understand, a fair degree of success.

It has occurred to me that a further economy of power might be effected by causing the sewage, with its burden of activated sludge, to travel spirally through a tubular chamber of considerable length not quite filled with the mixture at a velocity sufficient to entrain and hold in the liquid the air from the upper part of the tube. Where the sewage has to be lifted for treatment the discharge from the pumps might be utilized to set up this rotary flow, thus obviating the need for any special machinery for the purpose. Whether or not this suggestion proves to be feasible, there is little doubt that a way will before long be found to reduce very materially the power which is now expended in maintaining the necessary admixture of air and sewage, and that the activated sludge process will make good its place as a valuable method of purification.

Most of us can recall the time when the continuous production of a satisfactory effluent was an anxious and difficult task, absorbing all the energies of a sewage works manager. Those days, happily, have long since gone by. Unless he is hampered by inadequate capacity in his works, or by the unregulated discharge of trade wastes of unusual malignity, a manager can turn out with ease and certainty an effluent which will not injure the stream into which it flows. An exception might be made in the case of waters in which oysters are relaid, but even in such cases he has in chlorine an agent which can be relied on to prevent the conveyance of disease germs by the effluent. Had chlorination been available a few years sooner, certain seaside towns might have been saved the cost of the exceedingly expensive works which they have had to lay down. But it should always be borne in mind that the best and most effective precautions which can be taken against contamination by the dry-weather sewage will be of little avail if any storm water from the sewers is allowed to escape untreated.

Disposal of Sludge.—But although the anxieties of the sewage works manager with regard to the quality of his effluent have more or less disappeared, it does not follow that he is at the end of his difficulties. We have no sooner vanquished the sewage problem, when our enemy again confronts us in the form of sludge. We may compel it to do our bidding, as in the activated sludge process, but sooner or later was must dispose of it, and unless we do so promptly it will accumulate in portentous quantities, and be an ever-present nightmare on the chest of the unfortunate manager. The difficulty is aggravated by the enormous proportion of water which swells the mass of the sludge, and which ranges from nine times the weight of the dry solid in the case of a well-digested septic sludge to forty or fifty times in that of the activated material. The crux of the sludge problem is generally held to be in the removal of the surplus moisture, so as to reduce the bulk of the sludge and bring it into a manageable condition. This can be done by pressing, but the process is costly, and further expense has generally to be incurred in the disposal of the pressed sludge.

Some observations which I made many years ago on septic tanks at Exeter and elsewhere seem to point to the possibility of employing the sludge to press itself. It is heavier than water, and when immersed in water each particle exerts on those below a pressure due to this difference in weight. The lower layers are thus compressed, and a part of the contained water displaced. An examination made at Exeter in December, 1900, of a septic tank which had been in continuous use for four years showed a depth of sludge of about 4 ft., the percentage of moisture being, for the upper layer, 89 per cent. at mid-depth 84 per cent, and at the bottom 80 per cent. The comparative dryness of a well-digested and compressed sludge is well shown by its consistency (resembling that of a tough mortar), when forced through the cleansing valves of a tank by the pressure of the sewage; while if it is not drawn off regularly it sometimes becomes so compact that it refuses to move.

Such being the effect of compression in the comparatively shallow layer of sludge on the floor of a tank, it seems reasonable to expect that with a greater depth still more satisfactory results would be obtained. I have little doubt that septic sludge, if run or pumped into a shaft, which may easily be 20 ft., 30 ft., or even 40 ft. deep, would speedily become consolidated, a large proportion of the water which it contained rising to the top of the shaft and that in a comparatively short time the bottom layers might be forced out in a perfectly manageable condition.

Sludge as a Fertilizer.—While indicating the possibility of freeing sludge in this way from a large proportion of its superfluous moisture I am by no means sure that this would not be a step in the wrong direction. For the drying of sludge is merely a preliminary to its removal and in no way solves the problem of its ultimate disposal. I cannot help thinking that the proper destination of sludge is the land, and if it can be applied to land within a reasonable distance, it is surely better to keep enough moisture in it to enable it to be forced through pipes (either by gravitation, or by pumping) than to reduce it to a condition in which it must be carried. Apart from this consideration, it was shown by Dr. J. A. Voelcker, in his report of March, 1908, to the Royal Commission on Sewage Disposal, that a moist sludge is more valuable as a manure than a drier one.

In the disposal of sewage the avoidance of pollution must come first, and if it is a matter of choosing between adequate purification and crop production it is the crops and not the purification which must give way. But I am not convinced that these two desiderata cannot be reconciled. When our local authorities, quite properly, took the disposal of their sewage into their own hands, they had to buy land for the purpose. The acquisition of land for sewage disposal is a very costly business, and they, naturally, as a rule, bought no more than they could help. This land had, therefore, to be used to its fullest capacity for purification purposes, and the question of cropping had, necessarily, to go to the wall. But with fertilizers at their present prices, and the need for an increased production of good staring us in the face, ought we not to look into the matter anew, and see if a way cannot be devised for turning our sewage to useful account without detriment to its purification?

There must be within a short distance of many of our sewage works hundreds of thousands of acres of land which would benefit greatly from an occasional application of sewage, tank or filtered effluent, or sludge. Apart from the gain to the crops, the purification works, especially the filters, would benefit not a little from the partial or total rest which they would thus obtain. It ought not to pass the wit of our local authorities to devise terms for the supply sewage, effluent, or sludge, as might be desired, with due security for effective purification. At the worst, the facilities so afforded could be at once withdrawn from any occupier who might be found to abuse them.

The Future of the Municipal Engineering Profession in Great Britain

By B. WYAND,

Secretary of the Institution of Municipal Engineers. Address presented Jan. 21, 1920, at annual meeting of the Institution of Municipal Engineers.

Recent months have witnessed many happenings of a disquieting nature, and unless municipal engineers combine and work solidly together the next few decades may see the extinction of the profession for all practical purposes.

Municipal engineering has never, in this country, had a separate existence. Its followers are regarded as hybrids, in whose blood runs many strains. Civil engineering, architecture, mechanical engineering and electrical engineering are distinct professions, represented by powerful bodies. Scarcely any departmental committee or royal commission is complete without a "shining light" or two of one or another of these societies, with the inevitable sprinkling of gentlemen who, by the accident of birth or fortune, have their finger in every pie that is in the making. All rank, however, before the municipal engineer, even on such matters as road construction and sewage disposal. He comes in when work is to be done, for the simple reason that the work cannot be done without him!

Municipal engineers have only themselves to blame. They have frittered away every opportunity. Instead of standing up for themselves they have played second fiddle to what they please to term "the parent body," and that dear dignified old relative is now about to sell them a very large pup indeed. Every engineer is aware that the Institution of Civil Engineers is introducing a bill in the next session of Parliament, and various are the surmises as to what form it will take. We are assured on the one hand that all the bill asks is the prohibition of the use of the letters "C.E."; we are assured on the other hand that the bill seeks to prevent anyone who is not a corporate member of the institution from doing civil engineering work of any kind. The truth probably lies between the two; but in whatever way the bill is regarded it forms a crying danger to the municipal engineer, and it is important to hold in mind certain words contained in the questionnaire recently sent out by the institution "to obtain statutory powers to prescribe the qualifications and to conduct examinations for admission to the profession of civil engineering, to keep a register of civil engineers, and to prevent persons who are not duly qualified from holding themselves out as members of that profession." Ninety-seven per cent of the replies were in favor of the institution taking steps to obtain such powers. History does not tell us how the 3 per cent of negatives was made up. Possibly it is under lock and key now.

There is one thing quite clear, and that is civil engineering will, sooner or later, become a "close" profession. Possibly when that matures some form of examination will be made compulsory, which will place matters on a tolerably fair footing. It would be nothing but an outrage on common sense, and an imposition upon the public, if the Institution of Civil Engineers, as at present constituted, were to be allowed to rule the roost. Only a proportion of its members are qualified by examination. The remainder may be quite learned individuals, although it is unfortunate that their learning has not saved them from the humiliating necessity of scouring the country for signatures and resorting to many ignoble subterfuges in order to secure nomination and election. If civil engineering work is to be controlled by this institution, and if only those whom it approves of may undertake the work, then it is imperative that only such of its own unexamined members as may satisfy some independent body of individuals shall be admitted into the sacred preserves.

Another danger to the profession is afforded by the attitude of the Ministry of Health as regards fees payable to municipal engineers for State-aided housing schemes. Here we have the introduction by the architectural profession of the thin end of their wedge, and it will not be long before a bill will be promoted in their interests, excluding all but members of the Royal Institution of British Architects (examined or unexamined) from preparing plans not only of houses, but of any other buildings whatsoever. I do not propose to touch here upon that document known as "Housing Memorandum No. 2." It reflects small credit upon those who were parties to its framing. Here again municipal engineers should have stood solid against it, but the usual irresolution and lack of cohesion marked any attempt at action, and it has even been threatened that if too much protest is now made the concession may be withdrawn! And municipal engineers shivered in their shoes at the threat!

In Ireland matters are distinctly worse. The Local Government Board for Ireland were, under the provisions of the Housing (Ireland) Act, 1919, empowered to make rules for carrying the Housing Acts into effect "and in particular to prescribe the duties, conditions of employment, and qualifications of officers and other persons employed by local authorities in the execution of those acts." There was a proviso that nothing should be done without "consultation with the president of the Royal Institute of the Architects of Ireland." The way thus opened, the inevitable has happened, and no man can now carry out a housing scheme without the consent of the Royal Institute of Architects of Ireland. There is a joint committee, but that is only stage thunder. Unless a man is admitted on the "panel" he is disqualified. The mouse has to ask the cat kindly to allow him to pass!

Is it not somewhat of an anomaly that when protest is made to the Ministry of Health concerning the shameful treatment meted out to some official by his authority the reply is, "We have nothing to do with surveyors"? But when it comes to paying them a proper fee for extra duties undertaken, the Ministry has everything to do with them, even to the extent of seeing that they get practically no fees at all!

The Royal Sanitary Institute and the Institute of Sanitary Engineers (or the Institute of Plumbers for that matter) will, it may reasonably be anticipated, come next into the field, and only members of one of those bodies will be allowed to touch sanitary work.

As regards roads, everyone expects that, having regard to the Ministry of Transport, the surveyor will be assured of a living wage, and some measure of protection; but with the experience one has had of the defunct Local Government Board and the new Ministry of Health it will be as well not to place too much reliance on either of these. Red tape can strangle the best intentions. Every confidence may be placed in the gentlemen in whose hands the destiny of the road official may be said to rest; but no man can long play a lone hand. If municipal engineers want him to help them they must help him and not sit supine (as is their wont) waiting for the crumbs to fall into their mouth.

A startling indication of the way the municipal engineer—in common, in this instance, with the whole of the staff of the local authority—is treated has been afforded by the numerous "war bonus" circulars of the Local Government Board and the Ministry of Health. In the case of Civil servants the award was definite—it had to be paid to all classes and grades. When it came to the municipal engineer, the powers that be so craftily worked the matter as to leave it entirely in the hands of the local authority, with the result that almost every ditch has had to be fought. The Ministry could, with a stroke of the pen, have made the payment compulsory, but they have no interest in the officers of local authorities, and they chose the regrettable course they did.

Surely facts such as those should teach municipal engineers that they must rely solely upon themselves and their colleagues in the service. Government departments will give them no assistance, and will be roused into activity only when there arises the opportunity for cutting down their emoluments or for seeing that no such nonsense as security of tenure and fair treatment shall clog the wheels of the local authority. And yet, what does one see? Dissension and petty bickering rife in every direction—unity utterly discredited—unionism regarded severely askance—meetings on the most vital matters practically unattended—each man leaving it to his fellow to do something, and scarcely a man working whole-heartedly for the general welfare.

Now is the time for engineers to be up and doing. In a few years it may be too late. Petty differences must be sunk, and if amalgamation is yet impossible, community of working might do much. What the profession needs is one powerful body, controlled by all grades and officered by live men. It is without doubt the most important profession in the country, and it stands at the lowest level. Its status is a sorry joke. Every little town-planner, motorist road expert, housing faddist, tenants' co-partnership 5 per center, soap or cocoa trader, is regarded by the public as the superior, mentally and technically, of the municipal engineer; and the municipal engineer, instead of leaving such people and their schemes severely alone, plays up to them, attends their meetings and conferences, and feigns paroxysms of admiration at all he sees and hears. And these, too, are the gentlemen who are most free with their criticism. Having absorbed every ounce of brain from the municipal engineer, they point the finger of scorn at him, and the public follow the big drum.

I repeat again that the municipal engineer must stand up for himself. If he will not his days are numbered. One by one his duties will be taken from him and given over to the heterogenous collection of outside miscellanies which is on the increase every day. And of all the crops that have been raised during recent years, the town-planner and the housing expert are the most prolific. What they don't know about housing and town planning would fill half the volumes in the British Museum.

Estimating River-Flow from Rainfall Records

By LIEUTENANT-COLONEL J. E. E. CRASTER.

From Engineering, London, Jan. 2, 1920.

The simplest and most accurate way of ascertaining the amount of water flowing in a river is, of course, to measure it. But this involves taking continuous, or at least very frequent, measurements for a period of years. Unfortunately, very few measurements have been taken in the British Isles, and where they have been taken, the results are often discordant, and therefore unreliable. A much quicker way is to ascertain the rainfall in the catchment basin from meteorological records, and to assume that the flow in the river represents a percentage, or rather a mathematical function, of the total rainfall in the catchment basin. But in this case we are dealing with several unknown factors. American records show that the total flow in various rivers varies from .3 to .6 of the total rainfall. In fact, the river flow is not a fixed percentage of the total rainfall, but varies with local conditions.

Rainfall losses may be grouped under the following heads: Direct Evaporation, Transpiration, Percolation.

Direct Evaporation.—Direct evaporation takes place from the wet leaves of vegetation as soon as rain ceases to fall. If we know the amount of water required to wet a crop we shall have a measure of the amount of direct evaporation that takes place after each fall of rain. The amount of water required to wet a crop can be ascertained by watering it with a watering-can, fitted with a very fine rose, and noting when the water first begins to drip from the leaves on to the soil. In this way it was found that .65 in. of water was required to wet a crop of rough grass. The crop was the aftermath in a hayfield, and was about 5 in. in height. This particular crop was selected because it was considered to be the most typical crop for the whole country throughout the year. Some crops, of course, will require far more water to wet them, and others less.

In addition to land under grass, or other crops, there is a large amount of land which is ploughed in the autumn, and remains without a crop until the following spring. But ploughed land exposes a large surface to the air, and it has been proved that water evaporates more quickly from it than from the surface of a shallow tank. Taking all these points into consideration, it seems safe to assume that the amount of water required to wet vegetation, and the surface of ploughed land, is not less than .04 in.

The whole of this water is lost by direct evaporation after every fall of rain. So that the total amount of loss will be .04 in., multiplied by the number of days on which .04 in. or more of rain falls. (This number is given in the records published by the Meteorological Office.) On days on which rain falls to an amount less than .04 in. the loss may be taken at half this, or .02 in.

For any area we can calculate from the records of the rainfall stations, the amount of loss due to direct evaporation. Thus, for the northeast of England in 1918 the number of days with a rainfall of .04 in., or over, was 127; and the number of days on which rain fell to an amount of less than .04 in. was 67. The direct evaporation for this area will therefore be $.04 \times 127 + .02 \times 67$; that is 6:42 in.

Transpiration.—Unfortunately, few observations have been made in this country with regard to the transpiration of vegetation. Very careful experiments have been made in America, but the crops under observation were chiefly those grown in the Southern States, and therefore by no means typical of British crops. The following figures have been obtained from German records.

A beech wood transpires 14.2 in. of water per year; a crop of oats, 8.98 in.; a crop of barley, 4.88 in.; no figures are given for grass or heather, but it seems probable that they would approximate to those given for a crop of oats; that is, about 9 in. per year.

The amount of transpiration varies very greatly from month to month. The maximum occurs just before the plants reach maturity, and may then amount to a quarter of the total for the year. The following table has been compiled from American records, adjusted as far as possible to British conditions. It shows how much water will be lost by transpiration in each month, assuming a total transpiration for the year of 9 in.:

AMOUNT OF TRANSPIRATION.

Month.	Percentage.	Amount.
January	1	.09
February	1	.09
March	5	.45
April	8	.72
May	12	1.08
June	18	1.62
July	25	2.25
August	15	1.35
September	8	.72
October	5	.45
November	1	.09
December	1	.09
Total	100	9.00 in.

Percolation.—The amount of water lost by percolation is almost impossible to estimate. The records of large rivers show that the flow at the end of long periods of drought amounts to about 10 per cent of the total annual rainfall in the catchment basin. This is practically all percolated water, which has reappeared at the surface. Probably an equal amount percolates to greater depths, and is lost altogether. It is really a geological problem for which there is no general solution, and it can only be studied with the aid of detailed geological knowledge of the particular area under consideration. As a rough rule for areas of which the geological formation is not accurately known it seems safe to assume that the percolation losses are not less than 10 per cent of the total annual rainfall.

Summary of Losses.—For the northeast of England, where the total rainfall for 1918 was 26.8 in., the losses calculated on the method detailed above would be as follows:

	In.
Direct evaporation	6.42
Transpiration	9.00
Percolation (10 per cent of rainfall)	2.68
Total	18.10

The run-off will therefore be 26.8—18.1, or 8.7 in. per year. That is .325 of the total rainfall.

The northeast of England has a small fainfall compared with the rest of the country. Let us now apply the same method to an area with an excessive rainfall. At Fort William, in Inverness, the rainfall amounted to 78.7 in. in 1918. The total losses, as calculated above, would be 26.03 in., leaving a run-off of 52.67 in. That is .67 of the total rainfall.

Thus we see that according to the proposed method of calculation the run-off varies between .325 and .67 of the total rainfall. These figures agree very closely with the American observations of the actual flow in the rivers. The American figures being .3 and .6 respectively.

Rainfall Records.—It should be noted that the rainfall in any area increases with the height above sea-level. In hilly country, where the rainfall stations are situated in the valleys—as is generally the case—the observed rainfall will always be less than the actual rainfall. Unless this fact is taken into consideration the rainfall will be underestimated.

Storage Requirements.—From the table showing the amount of transpiration that takes place each month it will be seen that this occurs chiefly in the months of May to August inclusive, and amounts to 6.3 in. These are also the months of smallest rainfall. It may therefore easily happen that the whole of the rainfall during these months may be lost through evaporation and transpiration, and there may be no run-off at all. The only water in the rivers during this period will be water which has percolated into the soil during the previous months, and reappears in the rivers. This may be only 10 per cent of the annual rainfall. The balance required during the months May to August will have to be made up by storage.

It is not to be expected that the methods described in this article will give very accurate results. They are merely intended to show how the best estimate may be prepared from rainfall records.

Fungoid Growth in Sewers

By E. E. FINCH, M. INST. C. E.

From The Surveyor, London, Jan. 16, 1920.

The following account of the stoppage of a pipe-sewer through fungoid growth will, I think, be of interest to all those engaged in sanitary engineering, and shows the necessity for—

(a) Securing as far as possible perfectly tight joints.

(b) Seeing that no timber is left in actually touching the pipes.

(c) For further protecting the pipes with good concrete, so that no fungoid growths from any timber (which must of necessity be left in) can reach them, for, although the authorities at the Natural History Museum could not trace any connection between the fungus and timber submitted to them, and have no evidence that such a fungus grows on the wood of conifers, they hesitate to say definitely that such growth cannot occur.

Owing to repeated stoppages in a 12-in. pipe sewer at Crosby Square, E. C., openings were made and the sewer examined, when it was found that the sewer was practically choked by a fungoid growth. This growth was removed and portions submitted to the authorities at the Natural History Museum, South Kensington, who, after careful examination, pronounced it to be a species known as Fomes ulmarius—Cooke = Polyporus ulmarius Fries, which they state was only known to grow on live trees, particularly elm.

On further examination, a second piece of fungus, measuring only a few inches, was found 6 ft. further down stream, and beyond this a third piece, about 2 ft. long, and practically filling the pipe, as in the first case, 12 ft. 6 in. down stream from the first.

On breaking out the pipes a fourth fungoid growth was found in a disused 9-in. drain. This was about 1 ft. long, and completely filled the pipe.

The sewer was constructed with 12-in. stoneware pipes with bituminous joints. Some of the joints, however, were found to be slightly open, and some of the pipes slightly cracked. It was laid at a depth of 30-37 ft., and partly under buildings. Part of the sewer was embedded in concrete and part not. Partially rotten timber (probably the remains of the timber left in when the sewer was constructed) was found almost touching the pipes at the points where the fungoid growths were found. Specimens of the timber have been submitted to the authorities of the Natural History Museum, who state that the wood is from a conifer, and although there are slight evidences of fungoid growth, such growth is apparently in the nature of dry-rot, and not of the species found in the pipes. They suggest that elms may have grown at or near the spot and some of the roots been left in when the trees were cut down, the sewer being laid under the site of what was formerly Crosby Hall, and prior to that Crosby-place.

The City Librarian has kindly looked up the plans and prints in the Guildhall Library, but cannot trace any evidence to support the foregoing suggestion.

The ground in Crosby-square, examined at the opening nearest to the point where the fungus was discovered, was found to be made ground to a depth of 28 ft., and then bright water-logged gravel. This may be misleading, owing to the fact that this was almost undoubtedly a point where a shaft was opened when the sewer was constructed. Further down stream the heading now driven was probably wider than the original one, and was entirely in gravel.

The ground in Bishopsgate by the entrance to Crosby-square was found to be made-up ground to a depth of 22 ft., after which gravel was met for 15 ft., and then a bed of grey clay.

Flow in Uniform Channels When the Water-Surface Is Not Parallel to the Invert

By PROF. ALEX. H. JAMESON.

From Water and Water Engineering, London, Dec. 20, 1919.

In ordinary cases of flow in open channels of uniform section, the water surface is parallel to the invert, and it is to such "uniform flow" that the ordinary formulae apply whether of the Chezy form, $v = C\sqrt{mi}$, or in the much more satisfactory and modern form, $v = cm^x i^y$. For convenience, call the uniform depth of the water for a given discharge at a given gradient the "normal depth" for that discharge at that gradient in the given channel. If, however, the depth of the water is increased above the normal, e.g., by passing over a weir which can only pass the given discharge by raising the water surface there, the water surface can be no longer parallel to the invert, but forms a "backwater curve" for a long distance back before the water regains its normal depth. Similarly, if there is a sudden drop in the bed or the water passes over a weir which does not require to pass the given discharge, a head equal to the difference between normal level and weir level, the water surface forms a "drop-down curve" from the normal water level at a long distance back to the level necessitated by the weir or drop (which latter is similar in effect to a weir). In such cases the depth, water area, velocity and hydraulic mean depth vary along the channel, consequently so does the gradient of the water surface. In addition the "velocity head" $\frac{v^2}{2g}$ is constantly decreasing (or increasing) and the water surface must fall less (or more) steeply to provide for this change in the kinetic energy of the water. A third case of "non-uniform" flow occurs when the invert of the channel is level or rises against the flow. Here the water surface must fall, and as the depth decreases it must fall, as before, in a curved profile.

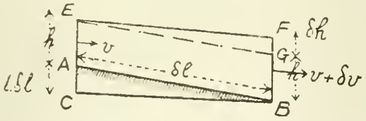
This subject is treated at considerable length in Gibson's and in Merriman's Hydraulics, but only for the case of a very broad and shallow channel of rectangular section (such as some rivers and canals), which is very different from the conduits used by water engineers. This has been done to employ a section in which the hydraulic mean depth equals the depth of the channel at every point, as this alone gives a purely mathematical solution. Even then the solution is one of considerable difficulty, and to simplify it tables of the "backwater" and "drop-down" functions for various values of $\frac{\text{depth}}{\text{normal depth}}$ have to be used. In addition, the Chezy formula is used to simplify the mathematics, but without varying the "constant" with the varying hydraulic mean depth, which, of course, is essential to obtain at all accurate results.

The author shows further on that if what he calls the "flow-function," $\phi = \frac{dl}{dh} = \frac{1 - \frac{v^2 b}{ag}}{i - i^1}$ is plotted as a curve for various depths, h, of the water in the channel, where v is the velocity for that depth, i.e., $\frac{\text{discharge,}}{\text{area}}$, b = breadth of the water surface, a = water area at that depth, g = 32.2 as usual, i = the gradient of invert and i^1 = the calculated gradient of the channel to discharge the given quantity of water at a uniform depth h, then the area of this curve between any two depths h_1 and h_2 = the length $l_1 - l_2$, in which the depth increases or decreases from h_1 to h_2. This function is not difficult to calculate once the water areas, and hence the velocities and hydraulic mean depths, have been found at a sufficient number of depths, while i^1 can be found by an "alignment diagram" from the hydraulic mean depths and velocities, or from charts giving gradients, hydraulic mean depths and velocities.

As shown, $\frac{1}{\varphi} = \frac{dh}{dl} = \frac{i - i^1}{1 - \frac{v^2b}{ag}}$ = rate of change of depth with length along the channel. When h = "normal depth," $i^1 = i$, the rate of change of depth is zero, and the depth remains constant. This is, of course, as it should be. When $\frac{v^2b}{ag} = 1$ i.e., when $v = \sqrt{\frac{ag}{b}}$ $(= \sqrt{gh}$ in a rectangular conduit), the denominator becomes zero, and the rate of change becomes infinite, i.e., the water surface becomes vertical, and a "standing wage" is produced. The depth at which this occurs may be called the "critical depth," viz., $\frac{v^2}{g}$ in a rectangular channel. In the neighborhood of this depth, however, the shape of the water profile cannot be determined exactly by this method, as there is a considerable inclination of the water surface to the bed so that the stream lines are far from parallel and the square of the mean velocity differs widely from the mean square of the velocities. There is also sure to be a loss of energy due to shock in the case of a "rising standing wave," similar to a sudden expansion in a pipe, while a "falling standing wave" is really a weir effect. For a level bed $i = 0$; while for a rising bed i is negative.

Usually the gradient i is small, and the "critical depth" is much below the "normal depth." In this case, if the depth of the water is reduced by a valve to or below the critical depth, a "standing wave" is produced, the water surface rising vertically to normal depth (see paper by Gibson in Proc. Inst. C. E., Vol. 197, in which this result was verified by experiment). If a channel has a very deep slope, and, therefore, low normal depth; in such cases, when depressed by a valve below normal depth, the surface rises in a gradual curve to normal depth, while when raised above critical depth—say, by a weir a standing wave is produced, and the water jumps the obstacle instead of ponding up behind it in a "backwater" curve.

The practical importance of these curves, if verified by experiment, is obvious. If the water engineer knows the shape of the water surface curve, the depth of his channel can be designed to follow it without waste of material in side walls of unnecessary height, or without risk of overflow or of putting pressure on his conduit if closed, through under-estimation.



In the figure let AB be a very short length of the invert of a channel of uniform section, and EF be the corresponding water surface. Let sin ABC = i. Let h and v be the depth and mean velocity at A, while $h + \delta h$ and $v + \delta v$ are depth and velocity at B. Then total head at A = total head at B + resistance A to B, or $i\,\delta l + h + \frac{v^2}{2g} = h + \delta h + \frac{(v + \delta v)^2}{2g} + i^1\,\delta l$ (where i^1 = loss of head per unit length for velocity v and depth $h = \frac{fv^2}{2gm}$, or better $K\frac{v^p}{m^q}$).

Then $i = \frac{\delta h}{\delta l} + \frac{v}{g} \cdot \frac{\delta v}{\delta l} + \frac{\delta v}{2g} \cdot \frac{\delta v}{\delta l} + i^1$. Now if δl and therefore δh and δv are reduced to zero, and this becomes $i = \frac{dh}{dl} + \frac{v}{g} \cdot \frac{dv}{dl} + i = \frac{dh}{dl} + \frac{v}{g} \cdot \frac{dv}{dh} \cdot \frac{dh}{dl} + i^1$, as v is a function of h only in a uniform channel. Therefore $\frac{dh}{dl} = \frac{i - i^1}{1 - \frac{v}{g} \cdot \frac{dv}{dh}}$ giving the slope of the water surface.

But $v = \frac{Q}{a}$ where Q is the constant discharge, therefore $\frac{dv}{dh} = -\frac{Q}{a^2}\frac{da}{dh} = -\frac{Q}{a^2} \cdot b = -v \cdot \frac{b}{a}$ as $\delta a = b\delta h$, where b = breadth of water surface. Therefore, $\frac{dh}{dl} = \frac{i - i^1}{1 - \frac{v^2b}{ag}}$ and $\frac{dl}{dh} = \frac{1 - \frac{v^2b}{ag}}{i - i^1}$. Therefore $l_2 - l_1 = \int_1^2 \frac{1 - \frac{v^2b}{ag}}{i - i^1} \cdot dh = \int_1^2 \varphi dh$ = area of φ, h curve from h_1 to h_2. In a rectangular conduit, b = constant, and a = bh. Therefore $\frac{v^2b}{ag} = \frac{v^2}{gh}$.

Relations of Labor and Capital

By PROFESSOR H. M. HALLSWORTH,

(Armstrong College, Newcastle-on-Tyne.)

From Engineering and Industrial Management, London, Jan. 1, 1920

The economic position at the present time is certainly one of great difficulty, but the outlook is far from being as hopeless as some people would have us to think. There are already signs that the position is improving. The percentage of unemployment as shown by the Board of Trade Returns has been steadily decreasing for some months, and the state of employment is distinctly better than it was for the average of the years 1909-1919, and there is considerable activity in the extension of old businesses and the starting of new ones.

The financial position, the state of the currency and of our foreign trade, are matters of grave importance to us all, and much might be said about them, but the question of the future organization of industry and the relations of Labor and Capital is a still more vital one to our prosperity. It would be idle to shut our eyes to the very serious and widespread mistrust of the employer and the capitalist on the part of Labor. I think this mistrust may be traced to three causes, namely, (a) attempts to reduce wages, hence the growing strength of trade unions and their alliances; (b) the feeling that workmen are losing control of the destiny of their own lives, hence the demand for control of industry and Sovietism; (c) the belief that labor alone creates wealth, hence the desire for nationalization and the disposition no longer to work to make profits for the capitalist.

This mistrust will have to be got rid of if we are to have not only industrial peace but increased production. How has this mistrust arisen? Many employers have been very short-sighted if not more severely to blame. Some of them have treated their men merely as hands to do their bidding; piece rates have been nibbled whenever there was a chance and the men have not been consulted as fully as they might have been without loss of anything vital to the employers, especially on matters which closely affected them. They have rarely realized what the American business man has long since grasped, that high wages, far from being an evil, are a good sign, and that it is not high wages but bad workmanship and a low output which are so ruinous to industry.

Labor, on the other hand, has adopted views as to organizing ability and to Capital which are absolutely untenable. Capital will be required whether industries are nationalized or not, and the nation can only get it, as the war has shown us, by paying the price in the shape of interest or by taxation. In the latter case, one result is seen in the attempt of some workmen to escape taxation by limitation of output. Organizing ability was never so urgently required as now, and clearly it will have to be even better remunerated than at present.

Labor cannot make any real progress until it recognizes this. Labor has never fully realized what nationalization means. Nationalization has become a sort of shibboleth by men who, aware of some of the evils of a competitive state, are captivated by the picture of a Socialist Utopia. Labor has never realized the crushing effect nationalization would have on initiative, on invention, on business zeal. National industries cannot take risks. It is because a business must pay that waste is avoided and a higher standard of efficiency maintained. Some of the more acute are becoming alive to this. Hence the demand for Guild Socialism. The fatal defect in such a scheme is that which the Guilds of the Middle Ages discovered. In the Middle Ages attempts were made to enforce the theory of the just price. But the just price can only be determined by putting a thing on a free market and seeing what it will fetch among free buyers and sellers. Let employers make it quite clear that they are willing to pay the highest wages possible provided only that the workmanship is good and the output sufficient.

My feeling is that it is a new spirit that is wanted in industry, not a change in its structure. We want more of the spirit of co-operation, comradeship and loyalty. There are extremists on both sides, but at heart the British workingman deeply loves his country; he is loyal to those whom he can trust; he is fair and reasonable when the position is clearly explained to him; he has a keen sense of justice and is responsive to generous treatment. Is it impossible for the employer to trust him a little more, to ask for greater trust in himself? If so, it is a black outlook for us. But I don't believe it. I believe that good will on both sides can be inculcated, if only we are determined to create it, and the fruitful results of this better spirit will astonish us.

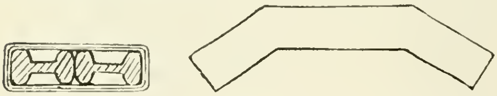
Cofferdam Formed of 20 Ft. Rails

From Indian Engineering, Calcutta, Dec. 13, 1919.

A cofferdam made of old rails was employed in putting in the foundations of the south abutment of the new Chittravale Bridge. The framing piles and cross struts were old 20 ft. 75 lb. rails, which were on hand lent, cost free, for loading the 12 ft. cast iron cylinders.

The south abutment of this bridge, with its wing walls, is of masonry founded on rock, in open excavation. The cofferdam was formed of piles each made of a pair of old 20 ft. 75 lb. double-headed rails, joined head to head by iron bands. Their lower ends were pointed and these were driven in line round the foundations 6 ft. apart from center to center longitudinally, and 20 ft. apart inside to inside transversely. Behind these mango planks 6 ft. by 1 ft. by 3 in. with planed and tarred edges were pushed and driven down from the top as the excavation of the interior proceeded; and when rock was reached, a wall formed of gunny bags filled with clay was made against the bed rock and planks to exclude outside sand and water as far as possible.

A water channel to a sump at each end was formed of similar bags and a No. 8 Pulsometer in each sump beyond these wing ends kept the dam dry.



The rail piles were strutted transversely by old 20 ft. 75 lb. rails forced down between them, to follow the excavation, the lowest one being 3 ft. from the bottom, the highest 1½ ft. from their tops; the other being spaced as found convenient and necessary.

The rock, which dipped rapidly, was cut into rough steps, all loose parts removed, and the foundation leveled up with concrete composed of 1 Portland cement, 2 sand and 4 of broken stone, by measure.

On this was built coursed hammer-dressed masonry. As soon as this reached the first row of tranverse rail struts, short timber struts were driven between each rail pile and the masonry, and the first row of transverse rail struts then removed; the remaining rows of rail stuts as reached were similarly dealt with.

After the masonry had in this way been built 2 ft. above water level the space between it and the plank sides of the dam was filled with earth well rammed, in layers; the planks being taken out row by row as the filling reached them.

The rail piles were drawn after the dam was filled up, so that all the materials used in its construction were recovered.

The maximum head of water against the dam was 13 ft., and the bottom rock was overlaid by 11 ft. of river sand.

Sewage Filtration Through Refuse Banks

By W. SCOULLER,

From Municipal Engineering and Sanitary Record, London.

House refuse has been disposed of at Chester for many years by raising low-lying land 10 ft. and covering with a top layer of 6 in. of soil. About 6 years ago the height of the refuse was reduced to 4½ ft., and the top layer of soil and subsoil increased to 18 in., and good crops have been obtained by this method.

In 1904 four acres of land on the sewage works site were covered with house refuse 10 ft. high, with the intention of building storm water filters theron. In 1910 a scheme of sewage works extensions was got out, which included the building of filters on this house refuse area. The cost was found to be heavy, and after alternative schemes had been drawn up and discussed, I decided to try the effect of direct filtration through the refuse bank.

A section of the bank was accordingly dug out and placed in an experimental filter, 3 ft. in diameter and 7 ft. 6 in. deep. The refuse was 10 years old, and consisted of ashes, bottles, crockery, bones, iron cans and general garbage. The filter was started in January, 1914, and treated crude sewage at the rate of 100,000 gal. per acre per day.

On march 7th, 1914, the rate of treatment was increased to 200,000 gal. of crude sewage per acre per day. The resulting effluent was of most excellent quality, the free ammonia almost entirely disappeared, and the nitrate was large. The rate of disappearance of dissolved oxygen in five days was small. The permanent hardness, however, was very high, and was mainly due to the solution of $CaSO_4$ from the refuse. An estimation of $CaSO_4$ in the refuse used was not made, but over ½ ton of this substance was dissolved out of the refuse per 100,000 gal. of sewage treated.

The analysis of experimental refuse bank effluent gave the following results:

Parts per 100,000.	Crude sewage.	Effluent		
		Feb. 1914*	Mar. 1914†	Apr. 1914†
Free and saline nitrogen	2.86	0.012	0.005	0.005
Albuminoid nitrogen	0.867	0.029	0.022	0.018
Nitric nitrogen	.....	3.1	5.0	4.8
Oxygen absorbed in 4 hours at 80° F.	11.68	0.38	0.40	0.40
Disappearance of dissolved oxygen in 5 days at 18.3° C.	.....	0.20	0.07	0.06
Hardness, temporary	.....	8.0	....	....
Hardness, permanent	.....	162.0	....	....

*100,000 gal. per acre per 24 hours.
†200,000 gal. per acre per 24 hours.

In May, 1914, the experimental filter having proved so successful, half an acre of the refuse bank was prepared and tank effluent distributed over it at the rate of 150,000 gal. per acre per day. The bank is not underdrained, and a well was sunk in it to enable a sample of the effluent to be collected at a depth of 4 ft. The results were excellent and confirmed the experimental filter. The analysis of the refuse bank half-acre filter showed the following:

Parts per 100,000.	June, 1914.	August, 1914.
Free and saline nitrogen	....	0.024
Albuminoid nitrogen	....	0.029
Nitric nitrogen	1.3	2.86
Oxygen absorbed in 4 hours at 80° F.	0.58	0.66
Disappearance of dissolved oxygen in 5 days at 18.3° C.	0.15	0.19

It now became necessary to know if fresh town refuse could be used for filtering sewage. The experimental filter was therefore emptied and refilled with house refuse fresh from the city in January, 1917. The weather was very frosty, but in 6 days nitrates appeared in the effluent, and in 16 days the effluent was of good quality. These results were surprising, when one considers that the refuse consisted of ashes, rags, old boots, bottles, bones, crockery, tin cans, etc. The filter, in fact, gave similar results to the old refuse filter, and is doing so to the present day. The average results of a number of analyses of fresh town refuse treated at experimental filter are as follows:

Parts per 100,000.	October, 1917.
Free and saline nitrogen	Trace
Albuminoid nitrogen	0.032
Nitric nitrogen	3.8
Oxygen absorbed in 4 hours at 80° F.	0.11

The scheme for using house refuse for sewage filters is briefly as follows: The land will be underdrained and the refuse raised 10 ft. with a top layer of soil 6 in. deep to act as a distributing layer for the sewage tank effluent.

Primary Stress-Determination in Space Frames

By R. V. SOUTHWELL,

From Engineering, London, Feb. 6, 1920.

The method to be described is applicable only to the determination of primary stresses, and the advantage which it has over the standard graphical methods to be found in any text book lies in its ability to deal with the stresses in three-dimensional frameworks, or "space-frames." When confronted with the problem of determining the primary stresses in the power units of a certain modern class of non-rigid airship, the author found that existing graphical methods were practically useless for his purpose, and he was thus obliged to devise new methods suited to this specific problem. Two methods were devised, one graphical, the other analytical: both were found to be adequate for the problem in hand, and their general applicability has suggested the writing of the present paper.

Only the analytical method is described here, since it has been found to have distinct advantages over the graphical method, of which perhaps the most important is its possible development to cover the problems presented by redundant frameworks and the calculation of secondary stresses. The practical advantages which seem worthy of mention are:

1. It is easily understood, and being almost completely self-checking requires no special skill in the operator (although, of course, facility with the method will enable results to be obtained more speedily).

2. It requires no instruments or drawing board, and no data beyond the dimensions given on ordinary working drawings, together with particulars of the applied load system.

3. The results are exhibited in a compact and convenient form, so that they can be easily revised and checked at any time. (The difficulty of checking the graphical work of another draftsman, in order to trace errors, will be familiar to any one who has had experience of these calculations.)

4. It is particularly economical in time when applied to problems in which it is required to calculate the stresses produced in a given framework by a number of different load distributions—and this generally happens in practical work.

It has been possible to illustrate this paper with an example of considerable practical interest, viz., the central ("Inchgarvie") pier of the Forth Bridge. An illustrated description of this bridge, published by Engineering in 1890, and now out of print, has supplied sufficient data to make the problem treated in Table I representative of actual conditions as regards both linear dimensions and the order of magnitude of the applied load system. The skeleton elevations and plan (Figs. 1, 2 and 3) have been prepared from Plate III of the work above mentioned; the deadweights have been estimated from the table of quantities given in page 63, and the wind loads by taking

TABLE I—EQUATIONS OF EQUILIBRIUM FOR FORTH BRIDGE CANTILEVER (FIGS. 1 TO 3).

(The External Load Term for the case considered is to be added to the Tension-Coefficient Terms, and the Sum equated to Zero.)

Joint.		Tension-Coefficient Terms in Equation.	Case I (Dead Load). External Load (Tons).	Case I Solution.	Case I Error (Tons).	Case II (Live Load). External Load (Tons).	Case II Solution.	Case II Error (Tons).	Case III (Wind Load). External Load (Tons).	Case III Solution.	Case III Error (Tons).
A	x	$-62\,t_{AQ} - 62\,t_{AB}$	0	$t_{AB} = -5{\cdot}37$	0	0	$t_{AB} = -1{\cdot}437$	0	0	$t_{AB} = 0$	0
	y	$33\,t_{Aa} - 3{\cdot}5\,t_{AB}$	0	$t_{Aa} = -0{\cdot}570$	0	0	$t_{Aa} = -0{\cdot}1525$	0	+114	$t_{Aa} = -3{\cdot}455$	0
	z	$48\,t_{AQ}$	−258	$t_{AQ} = +5{\cdot}37$	0	−60	$t_{AQ} = +1{\cdot}437$	0	0	$t_{AQ} = 0$	0
a	x	$-62\,t_{aB} - 62\,t_{ab} - 62\,t_{aq}$	0	$t_{aB} = 0$	0	0	$t_{aB} = -0{\cdot}128$	0	0	$t_{aB} = +5{\cdot}70$	0
	y	$-33\,t_{Aa} - 36{\cdot}5\,t_{aB} + 3{\cdot}5\,t_{ab}$	0	$t_{ab} = -5{\cdot}37$	0	0	$t_{ab} = -2{\cdot}149$	+0·01	+114	$t_{ab} = -5{\cdot}70$	0
	z	$48\,t_{aq}$	−258	$t_{aq} = +5{\cdot}37$	0	−138	$t_{aq} = +2{\cdot}875$	0	0	$t_{aq} = 0$	0
B	x	$62\,t_{AB} - 80\,t_{BP} - 80\,t_{BC} + 62\,t_{Ba}$	0	$t_{BC} = -5{\cdot}447$	0	0	$t_{BC} = -1{\cdot}525$	0	0	$t_{BC} = +4{\cdot}128$	0
	y	$3{\cdot}5\,t_{AB} + 40\,t_{Bb} + 3{\cdot}5\,t_{BP} - 5\,t_{BC} + 36{\cdot}5\,t_{Ba}$	0	$t_{Bb} = -0{\cdot}3235$	0	0	$t_{Bb} = +0{\cdot}0226$	−0·001	+47	$t_{Bb} = -5{\cdot}886$	0
	z	$57\,t_{BP} - 4\,t_{BC}$	−95	$t_{BP} = +1{\cdot}285$	0	−24	$t_{BP} = +0{\cdot}314$	0	0	$t_{BP} = +0{\cdot}290$	+0·01
b	x	$62\,t_{ab} - 80\,t_{bc} - 80\,t_{bC} - 80\,t_{bp}$	0	$t_{bp} = +1{\cdot}103$	−0·4	0	$t_{bp} = +0{\cdot}356$	0	0	$t_{bp} = -0{\cdot}249$	−0·1
	y	$-40\,t_{Bb} - 3{\cdot}5\,t_{ab} + 5\,t_{bc} - 45\,t_{bC} - 3{\cdot}5\,t_{bp}$	0	$t_{bC} = +0{\cdot}0313$	0	0	$t_{bC} = -0{\cdot}1333$	0	+47	$t_{bC} = +5{\cdot}65$	0
	z	$-4\,t_{bc} - 4\,t_{bC} + 67\,t_{bp}$	−95	$t_{bc} = -5{\cdot}292$	−0·06	−48	$t_{bc} = -2{\cdot}553$	−0·01	0	$t_{bc} = -9{\cdot}817$	−0·01
Q	x	$62\,t_{AQ} - 80\,t_{QC} - 80\,t_{PQ}$	0	$t_{QC} = -3{\cdot}853$	0	0	$t_{QC} = -0{\cdot}675$	0	0	$t_{QC} = 0$	0
	y	$33\,t_{Qq} - 8{\cdot}5\,t_{QC}$	0	$t_{Qq} = -0{\cdot}993$	0	0	$t_{Qq} = -0{\cdot}174$	0	+120	$t_{Qq} = -3{\cdot}64$	0
	z	$-48\,t_{AQ} - 52\,t_{QC} + 19\,t_{PQ}$	−95	$t_{PQ} = +8{\cdot}015$	−0·1	0	$t_{PQ} = +1{\cdot}787$	0	0	$t_{PQ} = 0$	0
q	x	$62\,t_{aq} - 80\,t_{qc} - 80\,t_{pq} - 80\,t_{qC}$	0	$t_{pq} = +8{\cdot}015$	+0·16	0	$t_{pq} = +3{\cdot}575$	0	0	$t_{pq} = 0$	0
	y	$-33\,t_{Qq} + 8{\cdot}5\,t_{qc} - 41{\cdot}5\,t_{qC}$	0	$t_{qC} = -0{\cdot}0022$	−0·09	0	$t_{qC} = -0{\cdot}1142$	0	+120	$t_{qC} = +4{\cdot}802$	0
	z	$-48\,t_{aq} - 52\,t_{qc} + 19\,t_{pq} - 52\,t_{qC}$	−95	$t_{qc} = -3{\cdot}853$	0	0	$t_{qc} = -1{\cdot}233$	−0·1	0	$t_{qc} = -4{\cdot}802$	0
k	x	$-262\,t_{k'k} + 185\,t_{kl} + 185\,t_{kf}$	0	$t_{kk'} = +14{\cdot}08$	0	0	$t_{kk'} = +2{\cdot}459$	0	0	$t_{kk'} = +7{\cdot}21$	0
	y	$-33\,t_{Kk} + 44{\cdot}5\,t_{kg} - 77{\cdot}5\,t_{kG} + 32\,t_{kf}$	0	$t_{kG} = -0{\cdot}664$	−0·9	0	$t_{kG} = +2{\cdot}52$	−0·7	+230	$t_{kG} = +3{\cdot}19$	+0·1
	z	$-337\,t_{kg} - 337\,t_{kG} - 47\,t_{kl} - 277\,t_{kf}$	−1040	$t_{kg} = -4{\cdot}85$	0	0	$t_{kg} = -3{\cdot}285$	0	0	$t_{kg} = -5{\cdot}14$	0
k′	x	$262\,t_{k'k} + 262\,t_{k'g} - 185\,t_{k'l'} - 185\,t_{k'f'}$	0	$t_{k'g} = 0$	+2·0	0	$t_{k'g} = -2{\cdot}459$	0	0	$t_{k'g} = 0$	0
	y	$33\,t_{K'k'} - 77{\cdot}5\,t_{k'G'} + 44{\cdot}5\,t_{k'g'} + 44{\cdot}5\,t_{k'g} + 32\,t_{k'f'}$	0	$t_{k'g'} = -4{\cdot}83$	+1·9	0	$t_{k'g'} = +2{\cdot}47$	−0·15	+230	$t_{k'g'} = -5{\cdot}15$	−1·0
	z	$-337\,t_{k'G'} - 337\,t_{k'g'} - 337\,t_{k'g} - 47\,t_{k'L'} - 277\,t_{k'f'}$	−1040	$t_{k'G'} = -0{\cdot}677$	0	0	$t_{k'G'} = -0{\cdot}011$	0	0	$t_{k'G'} = +3{\cdot}20$	0
G	x	$-262\,t_{G'G} - 262\,t_{GK'} + 185\,t_{GF} + 185\,t_{Gf} + 185\,t_{GL} + 185\,t_{Gl}$	0	$t_{GG'} = -4{\cdot}81$	0	0	$t_{GG'} = -3{\cdot}245$	0	0	$t_{GG'} = +22{\cdot}1$	0
	y	$122\,t_{gG} + 44{\cdot}5\,t_{KG} + 77{\cdot}5\,t_{kG} + 44{\cdot}5\,t_{GK'} + 12{\cdot}5\,t_{GF} + 109{\cdot}5\,t_{Gf} + 44{\cdot}5\,t_{GL} + 77{\cdot}5\,t_{Gl}$	0	$t_{Gg} = +2{\cdot}622$	0	0	$t_{Gg} = +1{\cdot}983$	+0·2	+392	$t_{Gg} = -18{\cdot}42$	0
	z	$337\,t_{KG} + 337\,t_{kG} + 337\,t_{K'G} + 60\,t_{GF} + 60\,t_{Gf} + 290\,t_{GL} + 290\,t_{Gl}$	$Z_G - 1920$	$Z_G = +4533$	0	$Z_G - 74$	$Z_G = +1426$	0	Z_G	$Z_G = -3514$	0
G′	x	$262\,t_{GG'} + 262\,t_{gG'} - 185\,t_{G'F'} - 185\,t_{G'f'} - 185\,t_{G'L'} - 185\,t_{G'l'}$	0	$t_{gG'} = 0$	0	0	$t_{gG'} = +3{\cdot}25$	0	0	$t_{gG'} = 0$	0
	y	$122\,t_{gG'} + 122\,t_{G'g'} + 44.5\,t_{K'G'} + 77{\cdot}5\,t_{k'G'} + 12{\cdot}5\,t_{G'F'} + 109{\cdot}5\,t_{G'f'} + 44{\cdot}5\,t_{G'L'} + 77{\cdot}5\,t_{G'l'}$	0	$t_{G'g'} = +2{\cdot}64$	0	0	$t_{G'g'} = -4{\cdot}26$	0	+392	$t_{G'g'} = -18{\cdot}42$	−2·0
	z	$337\,t_{K'G'} + 337\,t_{k'G'} + 60\,t_{G'F'} + 60\,t_{G'f'} + 290\,t_{G'L'} + 290\,t_{G'l'}$	$Z_{G'} - 1920$	$Z_{G'} = +4539$	0	$Z_{G'} - 44$	$Z_{G'} = -896$	0	$Z_{G'}$	$Z_{G'} = -3449$	0
g	x	$-262\,t_{gG'} - 262\,t_{gg'} - 262\,t_{k'g} + 185\,t_{gf} + 185\,t_{gl}$	0			0	$t_{gg'} = 0$	0	0		
	y	$-122\,t_{gG} - 122\,t_{gG'} - 44{\cdot}5\,t_{kg} - 44\ 5\,t_{k'g} - 12{\cdot}5\,t_{gf} - 44{\cdot}5\,t_{gl}$	Y_g	$Y_g = -279{\cdot}5$	0	Y_g	$Y_g = +359$	0	$Y_g + 392$	$Y_g = -3261$	0
	z	$337\,t_{kg} + 337\,t_{k'g} + 60\,t_{gf} + 290\,t_{gl}$	$Z_g - 1920$	$Z_g = +5677$	0	$Z_g - 149$	$Z_g = +2058$	0	Z_g	$Z_g = +3928$	0
g′	x	$262\,t_{gg'} + 185\,t_{g'f'} - 185\,t_{g'l'}$	0	$t_{gg'} = -15{\cdot}12$	0	0		0	0	$t_{gg'} = -14{\cdot}18$	0
	y	$-122\,t_{G'g'} - 44{\cdot}5\,t_{k'g'} - 12{\cdot}5\,t_{g'f'} - 44{\cdot}5\,t_{g'l'}$	$Y_{g'}$	$Y_{g'} = -278$	0	$Y_{g'}$	$Y_{g'} = -409$	0	$Y_{g'} + 392$	$Y_{g'} = -3261$	0
	z	$337\,t_{k'g'} + 60\,t_{g'f'} + 290\,t_{g'l'}$	$Z_{g'} - 1920$	$Z_{g'} = +5677$	−5·0	$Z_{g'} - 88$	$Z_{g'} = -745$	0	$Z_{g'}$	$Z_{g'} = +3930$	0

Fig.1.

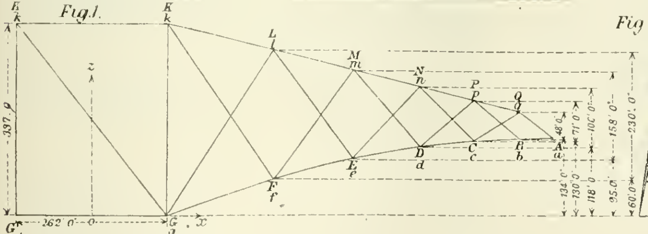


Fig 2.

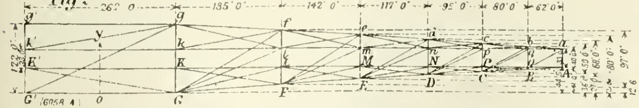
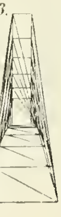


Fig 3.



a pressure of 112 lb. per square foot (according to the Board of Trade regulation referred to in page 9) to act over the estimated presented area of the structural members, the general dimensions of which are indicated at various points in the description; finally, the live load is roughly representative of the two trains used in the Board of Trade inspection and test, as described in the Appendix (page 71), these being imagined to stand on one of the two tracks, partly on the central towers and right-hand cantilever and partly on the central girder connected thereto.

It is worthy of remark that as regards the number of its principal members and joints this bridge satisfies almost exactly the conditions for a simple frame: the skeleton diagram of Figs. 1 to 3 differs from the actual bridge in little except that the horizontal bracing and one pair of diagonal columns have been omitted from the central tower, and that the viaduct and also the vertical ties throughout the span of the cantilevers and tower have been neglected, whilst a simple diagonal bracing has been substituted for the wind-bracing between the cantilever struts and for the bracing in the bottom chord members. Some account of the corrections to the results which are thereby necessitated are given in an appendix to this paper; for our present purpose it is obviously legitimate to make such simplifications as will bring the problem within the range of the method to be described, which aims only at the determination of the primary stresses in a simple framework. In their illustration of the difficulties which would be met in an attempt to use conventional methods of solution, this framework and load-system are excellent, many of the members being inclined to all three of the axial planes, and the cantilevers as a whole being twisted by the live load and wind forces which have been assumed to act upon them, so that the wind bracing of the struts is brought into play.

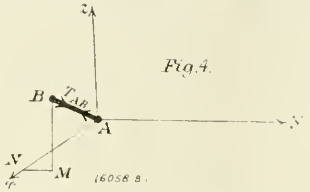


Fig.4.

We proceed to a general description of the method:

Notation.—We shall find it convenient to express the action in any member as a multiple of the length of that member, the positive sign being used to denote tension; thus, the tension in a member A B will be written in the form

$$T_{AB} = l_{AB} \, . \, t_{AB} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Then the component in the direction O x of the force exerted on the joint A (Fig. 4) by the member A B will be given by

$$T_{AB} \cos B A x$$

or by

$$t_{AB} \; (x_B - x_A),$$

while the component pull on the joint B, due to the same member, will be

$$t_{BA} \; (x_A - x_B),$$

so that (since by definition it it evident that t_{BA} and t_{AB} are identical scalar quantities) we have a self-consistent system for expressing forces on the joints, and signs will take care of themselves. The quantities t_{AB}, . . . etc., will be termed tension coefficients.

Equations of Equilibrium: First Check on Data.—Then if X_A, Y_A and Z_A are the components, in the directions O x, O y and O z respectively, of the external forces applied at the joint A, we may write the conditions for equilibrium of the joint A in the form

$$t_{AB}(x_B - x_A) + t_{AC}(x_C - x_A) + \ldots + t_{AQ}(x_Q - x_A) + X_A = 0 \quad \ldots\ldots (2)$$
$$t_{AB}(y_B - y_A) + t_{AC}(y_C - y_A) + \ldots + t_{AQ}(y_Q - y_A) + Y_A = 0 \quad \ldots\ldots (3)$$
$$t_{AB}(z_B - z_A) + t_{AC}(z_C - z_A) + \ldots + t_{AQ}(z_Q - z_A) + Z_A = 0 \quad \ldots\ldots (4)$$

B, C, ... Q being the joints which are directly connected with the joint A.

Three equations of the above types can be written down for each joint, involving unknown quantities, t_{AB}, t_{AC}, . . . etc., and known quantities $(x_B - x_A)$, $(x_C - x_A)$, . . . etc. We thus obtain 3 j equations in all, where j is the number of joints in the framework under consideration. But these are not all independent: for if we add together all the equations of the type (2) we can see that every term such as $t_{AB}(x_B - x_A)$ will be cancelled by a term $t_{BA}(x_A - x_B)$ from another equation, so that we are left with the relation

$$\left.\begin{array}{l} X_A + X_B + \ldots\ldots\ldots\ldots\ldots = 0, \\ \text{and similarly with the relations} \\ Y_A + Y_B + \ldots\ldots\ldots\ldots\ldots = 0 \\ \text{and} \\ Z_A + Z_B + \ldots\ldots\ldots\ldots\ldots = 0, \end{array}\right\} \ldots\ldots\ldots\ldots\ldots (5)$$

which must obviously be satisfied identically by the external forces, since they are conditions of equilibrium for the framework as a whole.

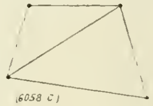


Fig.5.
BRACED QUADRILATERAL
(PLANE FRAME).

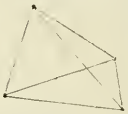


Fig 6.
TETRAHEDRON
(SPACE FRAME)

Again, if we multiply equation (2) by the factor y_A, and equation (3) by $-x_A$, and add, we obtain

$$t_{AB}(x_B y_A - x_A y_B) + \ldots + t_{AQ}(x_Q y_A - x_A y_Q) + y_A X_A - x_A Y_A = 0, \quad \ldots\ldots\ldots\ldots (6)$$

and if we add all the equations of the type (6) which can be obtained for the different joints, it is clear that every term such as $t_{AB}(x_B y_A - x_A y_B)$ will be cancelled by a term $t_{BA}(x_A y_B - x_B y_A)$ from another equation, so that we are left with the relation

$$\left.\begin{array}{l} (y_A X_A - x_A Y_A) + (y_B X_B - x_B Y_B) + \ldots = 0, \\ \text{and similarly with the relations} \\ (z_A Y_A - y_A Z_A) + (z_B Y_B - y_B Z_B) + \ldots = 0 \\ \text{and} \\ (x_A Z_A - z_A X_A) + (x_B Z_B - z_B X_B) + \ldots = 0. \end{array}\right\} \ldots\ldots\ldots\ldots (7)$$

These equations express the conditions that the external forces shall exert no resultant moment on the framework, and it is therefore obvious that they also must be satisfied identically. We have therefore two checks which can be made on the specified load system; unless (5) and (7) are satisfied, the frame cannot be in equilibrium, and it will be necessary to make such adjustments in the data (which will, of course, be based on estimated figures, and therefore liable to error) as are required to satisfy these conditions, before any progress can be made in the determination of the stresses.

Relations Between the Joints and Members in Simple Frames: Mechanisms and Redundant Frames: Second Check on Data.—Again, we have seen that our 3 j equations of the type (2—4) can be reduced to 3(j—2) independent equations; and the number of the quantities t_{AB}, t_{AC}, . . . etc., is equal to m, where m is the number of the tension or compression members in the framework. Then if

$$m = 3(j-2) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (8)$$

the loads in all members are definite and determinable from equations of type (2—4), which do not involve the elastic properties of the members. When this relation is satisfied, the framework is called a simple frame.

If m is equal to 3(j—2)—1, or to 3 j—7, we can eliminate the m quantities t_{AB}, t_{AC}, . . . etc., and obtain a new relation between the applied forces. The framework is now a mechanism, with 1 degree of freedom, and the relations between the applied forces are those which are familiar in the theory of mechanism.

If $m > 3(j-2)$, the quantities t_{AB}, t_{AC}, . . . etc., cannot be determined without reference to the elastic properties of the different members. In such a case, the framework is called a "redundant frame."

Relations similar to the above obtain in a framework which has all its members in one plane, and is assumed to be effectively held in that plane. The number of equations is now 2j (of the type of (2) and (3)), and of these 2j—3 are independent, since we have now two identities of the type (5), and one of the type (7). Thus the relation between j and m, for a simple plane frame, is

$$m = 2j - 3, \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (9)$$

while for a mechanism it is

$$m = 2j - 4.$$

As examples of simple frames, plane and three-dimensional, we may take the braced quadrilateral (m = 5: j = 4) and the triangular pyramid or tetrahedron (m = 6: j = 4) respectively, which can be seen (Figs. 5 and 6) to satisfy conditions (8) and (9) above. These conditions can, in fact, be obtained directly, by regarding "plane" (or two-dimensional) and "space (or three-dimentional) frames" as built up from the triangular and tetrahedron respectively. Consider first the plane frame: the first three joints require three members to fix them, and each additional joint requires two more; hence,

$$m = 3 + 2\,(j - 3),$$

which is the same as (9). Similarly, in a "space frame" the first four joints require six members to fix them, and each additional joint requires three more; hence,

$$m = 6 + 3\,(j - 4),$$

which is the same as (8).

It is only in the case of simple frames that the methods of this paper are sufficient to determine the stresses, and any specified framework should therefore always be checked over to verify that the problem is soluble. It is important to note that although the relations (8) and (9) must be satisfied in a simple frame, they are not necessarily sufficient. Imagine, for example, that we add additional members to a simple framework, in such a way that the first members added make the original frame redundant, while the last members added form a mechanism which is attached to this redundant frame as a base. Provided that the total number of members added is three times the number of extra joints thereby entailed, in the case of a space frame, or twice the number of additional joints entailed, in the case of a plane frame, the relations (8) and (9) will still be satisfied, although it is clear that the result of the additions has not been to produce a simple frame. For these reasons, equations (8) and (9) should not be used blindly, but in cases where any doubt exists as to whether a frame is simple or not, the members should be gone through carefully, to see whether the whole frame could be built up from the triangle or tetrahedron as a base, by connecting every other joint successively by just so many members, and no more, as will leave it fixed.

Pseudo-redundant Frameworks.—In certain cases it is legitimate to relax the limitations imposed by the relations (8) and (9). When, for example, any quadrilateral bay of a framework is braced by members connecting both pairs of opposite joints, a case of apparent redundancy is presented which will not be real, provided that the diagonal members are flexible (or of such small flexural rigidity that they are unable to sustain any appreciable load when acting as struts), and provided that they are not given an initial tension; only one of them can then come into operation at a time, under any ordinary system of loading, and it is unnecessary to count both in determining the value of m. If, on the other hand, as is customary in aeroplane construction, the cross-bracing members are initially tensioned one against the other, a case of real redundancy is presented, with which the methods of this paper are inadequate to deal.

Derivations of the Equations of Equilibrium: Checks on Their Accuracy.—Examination of the equations (2—4) will show that their form is exactly suitable for use with ordinary working drawings of frameworks, since the quantities $(x_B - x_A)$, $(x_C - x_A)$. . . . etc., can be determined at once from the leading dimensions which are shown thereon. Moreover, the drawings will indicate what joints are connected by members with any particular joint, so that the correct number of terms in any given equation is immediately evident. In proceeding to determine the stresses in a given simple framework, the first operation must be to write down all the equations of equilibrium. It is most important that careful regard should be paid to signs, and therefore, when the equations have been written down from a consideration of all the different joints in turn, they should be checked to see that any term which occurs, e.g., in the first equation of equilibrium for the joint B, and which represents the action of the member B C, also occurs in the first equation for the joint C, but with its sign changed. In addition, as has been stated above, the specified values of the external load components X_A, Y_A, . . . X_B, . . . etc., must be checked to verify that they satisfy exactly the six equations (5) and (7).

For facilitating the subsequent calculations and checking, it has been found convenient to take the joints in the order in which the equations will be solved (this is the reverse of the order in which they are taken when building up the framework as a test of redundancy); also, when writing down the three equations for any joint, to construct one of them first in symbols (thus ensuring that the proper number of terms is taken), and then to insert the appropriate values of the coefficients from a table of joint co-ordinates. This table will again be found useful when the lengths of the different members have to be calculated.

Solution of the Equations of Equilibrium.—When the equations of equilibrium have been written down, then form a series of simultaneous linear equations, from which the unknown tension-coefficients t_{AB}, t_{AC}, . . . etc., can be calculated; sufficiently exact solutions can in most cases be obtained with an ordinary 10-in. slide rule. By choosing a suitable joint as a starting point, we can almost always arrange our work so that not more than three simultaneous equations have to be dealt with at a time. It is important, in determining the value of a tension-coefficient which will appear again in another equation, to work to the utmost degree of accuracy which is considered essential, since any error will affect subsequent coefficients as well. A good method of procedure is to arrange the equations of equilibrium below one another in one column, and to write down the values of the tension coefficients in another column, in such a way that the particular tension-coefficient which is determined from any given equation, and the value obtained for it, appear opposite that equation. In a third column can be written the resultant error in the equation (or amount by which the left-hand side differs from zero when the calculated values of the tension-coefficients are inserted). Thus, when a group of equations are solved simultaneously, they should be bracketed in the first column and the derived values for the tension-coefficients bracketed in the second; there will, in general, be a finite error for each of the equations, which should be specified in the third column. When, on the other hand, enough terms are known in any equation to enable us to reduce it to a simple linear equation for one unknown tension-coefficient, the resultant error tabulated will of course be zero.

This method of exhibiting the results will indicate, for subsequent reference, the order in which the equations have been taken; it is illustrated by Table I, which refers to the Forth Bridge pier described in the introductory paragraphs, under three different conditions of loading, viz., dead load, wind

TABLE II—CALCULATED STRESSES IN FORTH BRIDGE CANTILEVER (FIGS. 1-3).

Member.	A B A'B'	A a A'a'	G L G'L'	GK'	g G	g G'	G'g'	g g'
Tension coefficient, Case I	—5.37	—0.570	—0.709	0	2.622	0	+2.64	—15.12
	—1.437	—0.1525	+0.00402					
Tension coefficient, Case II	0	0	0	—2.80	1.983	+3.25	—4.26	0
Tension coefficient, Case III	0	—3.455	+1.80	0	—18.42	0	—18.42	—14.18
Worst tension conditions	.....	.....	I+II+III	.....	I+II	I+II	I	.....
Maximum positive tension coefficient	.....	.....	1.10	.....	4.605	3.25	2.64	.....
Worst compression conditions	I+II	I+II+III	I	I+II	I+III	.....	I+II+III	I+III
Maximum negative tension coefficient	—6.81	—4.178	—0.709	—2.80	—15.798	.....	—20.04	—29.30
Length of member (feet)	62.09	33.00	352.6	429.2	122.0	289.0	122.0	262.0
Maximum tension (tons)	.....	.....	388.4	.....	562	940	322	7680
Maximum compression (tons)	422	138	251	1203	1930	.....	2442	.....

TABLE III.

	Size and material				Tension		Compression.		
	Member.	Length in inches.	Cross-section.	Specification.	Max. tension in lb.	Factor of safety.	Max. comp. in lb.	Factor of safety.	Remarks.
Tubular frame members.	A B, C D	29	1½ in. O.D. by 22 S.W.G.	T. 6	378.1	23.7	340	14.7	
	E Q, F R, G S	50	1¾ in. O.D. by 22 S.W.G.	T. 6	.....	....	...	....	Dimensions determined by lateral loads.
Wood members	A M, B N	50	Shaped	V. 1	.....	....	...	....	Engine bearers.
Bracing wires	C G, H S	..	45 cwt. (item 53)	W. 2	947.2	5.3	...	....	

forces and live load.* The equations of equilibrium will be seen to be practically the same, for the same framework, under any load systems, the external load terms (X_A, Y_A, . . . etc.) alone being changed; and the results of several determinations can therefore be exhibited compactly in the same table, if the external load terms are kept in separate columns from the other terms in the equations, which need then only be written one. Each system of loading is treated as a special case, and for each case three columns are used, the first containing the external load terms, while in the second and third are written down the calculated values of the tension-coefficients, and the resultant errors, as described above.

Several labor-saving devices suggest themselves when the analytical method is employed in practice. For example, when there is symmetry in the loading, the number of equations can be largely reduced; thus, only one side of the Forth Bridge cantilever is shown in Figs. 1, 2 and 3, and included in Table I, since the live-load stresses (due to train and weights) are confined to this side, while the stresses produced by the dead load and wind forces can obviously be written down for the other side from considerations of symmetry. It is found best, as soon as any particular tension-coefficient is determined, to substitute for it at once in all other equations in which it occurs; the suffix of the symbol indicates in what equations it may be expected and it has already been pointed out that every term occurs in two equations, with opposite signs. All work done may be regarded as correct until a serious "resultant error" is met with, and these errors may be expected to have their greatest values at one or more of the joints at which loads are applied. The resultant error in any equation can be seen to represent the magnitude of the additional force which would need to be applied at the joint, and in the direction concerned, to be in equilibrium with the calculated forces in the frame members, and it is thus easy to form an estimate of its seriousness, by considering it as a fraction of the external load component.

Reference has been made above to the "pseudo-redundancy" exhibited by crossed wire bracing. It was remarked that only one of the pair of wires, unless an initial tension is given to them, can be in action under a definite system of applied loads; but it is not in general possible to predict which of the wires will go slack, and for this reason (and also because both of the pair may come into operation at different times when there is a series of load systems to be considered, and we want to use the same equations for all the systems) it is best to retain both, but to employ some method of indicating these pseudo-redundant members in the equations, and when solving the equations relating to any pair to try the effect of disregarding each in turn; it will be found that by neglecting one we obtain a positive (tension) value for the tension component of the second, while by neglecting the second we obtain a negative (compression) value in the first. Only the first result is admissible, and thus we can tell which of the pseudo-redundant members should be neglected. Notes should be substituted in the "solution column" to show the members which go out of action.

The above considerations do not arise in connection with the example here treated, but are of frequent occurrence in aircraft work. In cases where an initial tension is given to each of a pair of crossed wires, the effect of applied load is felt on both, the tension in the one being increased and in the other diminished. The conditions of static equilibrium can now be satisfied in an infinity of ways, and the correct solution is not determinable without reference to the elastic properties of the wires. The frame is in fact truly redundant, and presents a problem which lies outside the scope of this paper.

Presentation of Results.—For the purposes of this paper we shall assume that a knowledge of the primary stresses is considered sufficient for the problem in hand. Then the data required for designing each member are the maximum tension and compression which it has to sustain, and its length. A convenient method of presenting the results is illustrated by Table II. Each member (or pair of symmetrical members) has a column to itself, and the values of its tension-coefficient, corresponding to the different load systems considered, are tabulated on separate lines. (It may be mentioned that the calculations for airship power units generally extended to five cases.) On the next two lines below these are indicated the load system for which the tension-coefficient has its greatest positive value, and the magnitude of this value, while below these again are shown the case corresponding to worst compression conditions, and the greatest compressive value of the tension-coefficient. Finally, multiplying the greatest positive and negative values of the tension-coefficient by the length of the member, we obtain the actual values of the maximum tension and compression which the member has to sustain, and these are inserted in the last two lines of the table. It is hardly necessary to add that the length of a member A B is given by

$$l_{AB} = \sqrt{(x_B - x_A)^2 + (y_B - y_A)^2 + (z_B - z_A)^2} \quad \ldots\ldots\ldots\ldots (10)$$

It is found convenient, when the design is completed, to compile a schedule of dimensions, which will show at a glance the factor of safety allowed in each member. The best form of tablulation will vary slightly with the problem in hand. Table III is based on the results of experience in the design of airships, and has been abstracted from an actual drawing, which has no reference to the problem considered in this paper. The factors of safety given in the first line are of course much higher than is necessary in aircraft work, and occur only because the dimensions of the member in question were settled by other considerations than those of direct strength.

Detailed Calculations for Forth Bridge Structure.—For the convenience of readers who wish to obtain a practical acquaintance with the analytical method, this article shall be concluded with a description in detail of the actual calculations from which Tables I and II have been constructed.

As a preliminary, some particulars of the assumptions made in calculating the applied forces may be of interest. The total dead weights for the different sections of the pier follow the published figures very closely, and have been distributed roughly on the principle of taking the weight per foot run of the tubular compression members to be twice that of the lattice ties; similarly, the lattice girder work has been assumed to offer to wind load one-quarter as much presented area per foot run as a tubular member of the same breadth. The two trains, each taken as 960 ft. long and weighing 1 ton per foot run, are assumed to be standing on the same track (the back track as viewed in Fig. 1), meeting at the junction of the cantilever and central girder, so that one train increases the total weight of the central girder, and thus the external loads acting on the end joints of the cantilever, while the weight of the other train is distributed over the joints of the cantilever. The two tracks are assumed to divide the width of the bridge into three, so that the train loads are distributed between front and back joints in the ratio 1:2. Wind forces are assumed to be distributed equally between front and rear joints, and all the live loads are considered to be transmitted from the track to the bottom joints only. The wind load due to the central girder has been taken to be equal to the total wind load on the last three bays of the cantilever, and to be divided equally between the four points of junction.

The test for redundancy must first be made. An inspection of Figs. 1—3 show that in the complete pier of two cantilevers (as there simplified) the number of joints is 52, and of members 149; thus $m = 3j - 7$, and this is the relation for a mechanism. The difficulty thus presented is only apparent, however, because the conditions of fixing are such that the four joints G, g, G′, g′, are constrained by the foundations of the pier to remain in one plane. If the framework had been completely braced in itself, the vertical components of the reactions at these joints would have been statically indeterminate. As it is, the horizontal components of the reactions are to some extent arbitrary; but it is reasonable to assume, in the absence of further information, that the x-component vanishes for each of the four joints, and the y-component for G and G′. In any case, the validity of these assumptions is not of much importance for our present purpose, which is to determine the stresses set up by specified loads at the joints. What the magnitudes of these loads have been assumed to be, in the three cases considered, may be seen by inspection of the left-hand (External Load) columns of Table I.

The next operation, in the routine procedure described above, is to check the specified load system in order to ensure that it is a system in equilibrium. In the present example this need does not arise, because the resultant actions at the joints G, g, G′, g′, have been left undetermined in the initial stages, and will be obtained in due course from the ordinary equations. The solution of the equations is started from the end of one cantilever and carried up to the central tower, at which stage further progress becomes impossible until the equations for the other cantilever have been solved. In the first two cases (viz., dead loads and wind forces) the stresses in the second cantilever can be written down by symmetry, and in the third case (live load) only one cantilever is affected. By this simplification the size of Table I was reduced very considerably, whilst the use of accented letters for the joints of the lefthand cantilever makes it easy to tabulate the symmetrical values.

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*Considerations of space have prohibited the reproduction of Tables I and II in their entirety (Table I includes 34 joints, and therefore 102 equations, and Table II nearly 100 columns); but it is hoped that even in this abridged form they will serve to illustrate all important features of the method.

Equations which have been solved simultaneously have been bracketed together. It was frequently found that the first and last equations for a given joint had to be taken together, while the middle one gave the third unknown by direct substitution. This process has been indicated by placing one-half of a bracket against the first equation and the other half against the last.

In forming Table II, only one column has been used for each pair of symmetrical members, and where their calculated tension-coefficients are different both have been written down, in an order agreeing with that of the members at the head of the column. Actually, of course, either member of the pair may be subjected to the greater load, and hence only one value (the greatest which occurs in either member) is inserted in each of the spaces left for worst tensile and compressive conditions.

Fig. 7.

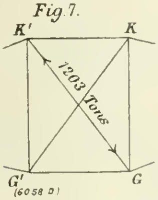


Fig. 8.

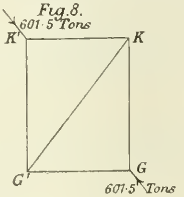


Fig. 9.

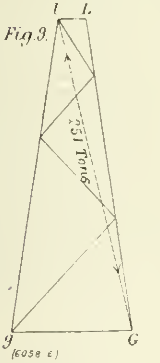
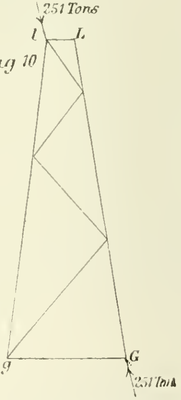


Fig. 10



Correction of Results to Allow for Actual Instead of Simplified Wind-bracing, Etc.—Although strictly outside the scope of this paper, it seems desirable to add a note showing how the stresses which have been calculated for the simply-braced framework of Figs. 1 to 3 may be subsequently corrected so as to take more complete account of the actual bracing of the bridge.

Figure 7 illustrates the bay K′G′GK of the central tower, which has in reality two diagonal members, K′G and G′K. In the preceding calculations, where G′K was neglected, the compression in K′G (Case II) has been found to be 1,203 tons. Let us now assume that only half this load actually comes on the member K′G; then it can be seen without difficulty that in making this assumption we are in effect putting on additional forces of 601.5 tons at the corners K′, G, and acting in the line K′G, which are resisted by actions in the other diagonal KG′ and in the side members KK′, K′G′, G′G, GK, as shown in Fig. 8. These actions are readily determined by graphical methods (since we are now dealing with a plane frame) and must be added (algebraically) to the actions previously calculated; it is clear that we shall be imposing as a tension in the member G′K the load (601.5 tons) by which we have reduced the compression in GK′.

A similar treatment will take account of the actual wind bracing. Fig. 9 shows this bracing in the bay L, l, g, G; to keep the frame "simple," only one of the two independent systems of wind bracing has been retained, since, if it is considered desirable, we can subsequently transfer half its load to the other system, in the manner just described. The calculated compression in G l (Case I) is 251 tons, and hence if we discard this fictitious member we are in effect introducing forces of 251 tons at l and G, and in the line G l, which are resisted by actions in the actual bracing and in the principal members L l, l g, g G, G L, as shown in Fig. 10. These actions can be determined graphically, as before, and the appropriate correctons made to the results of Table II.†

It is obviously an advantage to employ these artifices in dealing with a complicated space-frame; i.e., to shorten the analytical work by simplifying as far as possible the component plane frames, and to correct subsequently by means of graphical methods.

Progress on British Housing Program

From The Surveyor, London, Dec. 26, 1919.

Not the least interesting part of the final annual report of the Local Government Board, to which we referred generally last week, is that which deals with housing and town planning. It is admitted at the outset that during the financial year 1918-19, with which the report is concerned, the general shortage of housing accommodation has become increasingly serious, and further that, even after the terms of Government financial assistance were first announced, many local authorities hesitated to commit themselves to schemes for fear of involving their districts in too heavy a financial burden. Hence the famous circular of February 6th last, by which it was definitely provided that for schemes submitted within twelve months and carried out within two years or such further period as might be approved, the burden on local authorities would be limited to the amount produced by a penny rate. The public, who are the immediate sufferers from the house famine, will naturally ask what practical results have been achieved, and the answer to this question, which may be gathered from the report, will hardly raise enthusiasm. At the end of the year under review 358 authorities had submitted proposals relating to 658 sites; of which 227, comprising about 5,000 acres, had been approved. Of these 5,000 acres the lay-out of only 500 had been sanctioned, while house plans had been approved with regard to only 2,133 houses. The most encouraging feature of the situation lies in the fact that the greater part of this limited output of schemes, and plans took place in the last three months of the year, and there is reason to believe that this rate has been maintained during the period subsequent to that covered by the report. It must be realized, however, that the country is still a long way from overtaking its very heavy arrears of house building, and it is to be hoped that the latest Government Act will materially help in this respect.

Willow Trees and Sewage Farms.—The experience of the Chelmsford Corporation in growing willows on its sewage farm is worth noting. The particular variety of willow is the Salix alba, var. corulea. The setts may be planted at any time between November and March. From 250 to 350 trees should be planted to the acre, and the produce of an acre in from 12 to 15 years should yield £750, or £50 per annum, the cost of planting being about 30s. per 100 trees.—Water and Water Engineering.

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†The corrections to the stresses in the members l g and L G will, of course, vary over different portions of their lengths.

Controlling Inrush of Water in Tunnel Driving by Reinforced Concrete Dam

By THOMAS BLANDFORD,

From the Journal of The South African Institution of Engineers, Johannesburg, January, 1920.

A ferro-concrete dam was constructed in the 3-19 raise at No. 1 Shaft, Modderfontein East, Limited, for the purpose of controlling and closing off a feeder of water which had been encountered, and yielded approximately 1,000,000 gal. per day at a pressure of 500 lb. per square inch.

This outburst was cut in the dyke through which the raise was being driven, and was found to be coming from a vertical fissure striking north and south. This fissure was found to be filled to a large extent with soft clay, but evidently not sufficiently solid to resist removal by the water under pressure, with the consequence that as soon as the water was tapped in small quantity a portion of the clay filling was quickly washed out, and, furthermore, the dyke material adjacent to the fissure, being of a broken and loose nature, was displaced by the flow of the feeder until a cavity about 18 in. wide, 6 to 10 ft. long and 10 to 15 ft. high was created at the south top corner of the face.

Fortunately the dam was constructed and finished before this continuous stripping action was able to extend across the whole width of the face, thereby preventing a further increased flow of water.

As soon as it was found that any temporary measures for reducing the quantity of water were useless, work was immediately taken in hand to build a ferro-concrete dam. A good concrete, consisting of 1 cement, 1 sand and 2 broken stone (dyke material on site), was well rammed into the face to a thickness of approximately 4 ft.

No hitches for support were cut in the rock, but a series of 40 lin. steel pegs were driven to a depth of 1 in. to 9 in. into the rock in two rows around the perimeter of the drive, such pegs projecting a distance of about 1 ft. 6 in. into the mass concrete. In addition to this, two rows of ½-in. bar iron, one vertical and one horizontal, the bars being also about 1 ft. apart, were embedded into the concrete during construction and tied up by means of wire to the above-mentioned pegs, thereby forming a double grille system of reinforcement. In this way a thoroughly strong wall was obtained.

The feeder of water was confined behind the concrete to as small a channel as possible with the aid of 21-gage steel sheets, and released through two 6-in. pipes fitted with stop valves. By this means it was possible to place the concrete in position correctly without any interference from the water. Six 1½-in. cementation pipes were also built in the dam for the purpose of filling and solidifying the fissure and the subsequent testing of the ground in advance. While this work was in progress three release holes were drilled into the hanging wall from the front of the dam at an angle of 45°, thereby intersecting the fissure approximately 12 ft. above the hanging of the raise, water being tapped in each of these holes.

The work of construction of the dam occupied two days, after which it was allowed to set for 3 days. During this period the feeder was flowing freely from the 6-in. drain pipes.

Injection was then started, and continued 8 days, when all the pipes in the dam had been solidly closed with cement, and also two of the release holes in the hanging wall. At this stage approximately half the original feeder was shut off, but, owing to shortage of cement, it was not deemed advisable to close it all off, as there was no cement on hand should anything unforeseen take place by totally closing off the water, taking into consideration the short period that had been allowed for the maturing of the concrete. If sufficient cement had been available the work would have been completed in one operation at this stage. Sufficient cement was obtained 4 days later, and injection continued, for one day when all the release holes in the hanging wall were completely finished, thus effectively shutting off all water.

A quantity of 4 tons 14 cwt. of cement was used in the concrete construction. A quantity of 25 tons 9 cwt. of cement was injected at pressures ranging from 25 lb. to 220 lb. per square inch, giving a total quantity of 30 tons 3 cwt. cement used for closing off this fissure.

The total time occupied upon the construction of the dam, including the necessary injection of the fissure, to enable the feeder to be completely shut off, was 14 days. The total cost entailed in the construction and injection of the dam was £397 16s. 8d.

After completing the dam and shutting off the water, the mode of procedure consists of testing the ground in advance by means of boreholes, and, if additional water-bearing fissures are cut, cementation is conducted, so that the drive may subsequently be extended through the water zone without encountering water, the ferro-concrete dam being in the first place removed by blasting.

The chief advantage of this system of dealing with an inrush of water, apart altogether from its small cost, lies in the fact that whereas the water is easily dammed back and placed under control, it is unnecessary to abandon the drive altogether, as would be the case if any one of the ordinary types of underground dams is used. Furthermore, if desired, it is possible to again tap the feeder of water for industrial purposes by boring from the drive into the ground to a point in the fissure or fissures which is beyond the limits of the cemented area that envelopes the drive throughout the water-bearing zone.

Psychology in Relation to Industrial Management

From Engineering and Industrial Management, London, Feb. 12, 1920.

The psychology of the workingman is not essentially different from that of any other individual, but employers and managers have assumed that it is different. This assumption is an error of judgment and an obstacle in effective industrial management. The latter depends, as we have seen, on the one hand on the knowledge of materials and natural forces, and the other on human nature. To handle men it is necessary to know them, and to know men means their psychology, their motives, their attitudes towards the world in which they live and work.

Modern industry gives the laborer's instincts of workmanship and self-expression little scope. Two reasons have been advanced for this: in the first place, actual industrial processes have been reduced very largely to routine tasks, and the responsibility thrown upon most workers has been reduced to a minimum. In the second place, the instinct of self-expression is violated by the autocratic administration of industrial establishments, and it appears quite evident that unless a factory administration is so arranged that the workmen have a voice, at least a consultative voice, in co-operation with the representatives of the employers in the management of all the conditions pertaining to labor in the factory, we may be fairly sure that unrest and discontent will continue to exist.

Production managers make all physical arrangements of the plant with little or no personal conference with the employes. Wage rates, hours of labor, and working conditions are fixed either in the autocratic manner in which the individual laborer is approached in a spirit which leaves him with no choice in the matter, or as the result of formal conference for collective bargaining between the employer and the higher representatives of organized labor, with whom the rank and file rarely come into direct contact. Changes in processes which may involve the discharge or reduction in wages of a large number of employes, introduced without consultation with those men concerned, is a fertile source of trouble. Such proceedings, of course, take place on the old legal and economic theory that a man's business is his own to handle as he thinks fit. It should be fairly evident that this theory tacitly regards the workman as entitled to no more consideration than the material equipment of the plant. It neglects the human factor in industry. There are still employers who refuse to admit that the worker has a vested interest in his job, even though upon his job depends his own livelihood and the life of his family. It should be pointed out, however, that the workman does have a vested interest in the psychological sense in his job, and that failure to recognize this often results in repressed desires and disappointment, which play no inconsiderable part in the causation of industrial unrest and inefficiency in production.

All unrest being due to thwarted desires and repressed instincts, it follows that the causes of industrial unrest may be stated in psychological terms. Unrest arising from what the workman regards as insufficient wages is usually due to unsatisfied desires tor the attainment and maintenance of a standard of living physical and social—above that which his actual wages will support. In this, desires for self-expression, distinction and recognition involve imitation and emulation of those who set the standards of repute. The wage level, together with the hours of work, thus occupies a strategic position of the determination of the worker's psychology, because upon the amount of his wage is determined in a large measure the spiritual level of his existence. It would be an error, however, as already suggested, to assume that raising wages and shortening hours of labor would remove all the important causes of industrial unrest. There would still remain unsatisfied desires for self-expression and for a measure of self-government, without which self-expression is impossible. It is not to be supposed that all the workmen want is high wages. From a mere monetary point of view, employers do well to recognize that there are other powerful motives for honest and efficient work, and that to the extent to which these motives can be brought into play in personal interest in the work in hand and in community interest in factory organization and functions, individual restlessness and the industrial unrest to which it tends will be diminished, and peace and efficiency attained, possibly at a lower wage than would otherwise be feasible. In other words, it is possible that if workers had more voice in the government of the intimate details of industry they would make fewer demands for impossible wage terms.

Overturning Moment on Retaining Walls

By ANGUS ROBERTSON FULTON.

Abstract of paper read Feb. 10, 1920, before the Institute of Civil Engineers.

Experimental methods of investigating the pressure of earth on retaining walls have usually followed one or other of two directions in the attempt to decide between the claims of two main theories—the theory of prism of maximum pressure and Rankine's theory of conjugate pressures.

The aim of these methods was either to obtain the ratio of the conjugate pressures directly or deductively by experiments, or to determine the overturning moment on the wall. In the latter case indirect means, such as the stability or failure of the wall, were used, or direct measurements were made. In the present investigation the method of direct measurement of the overturning moment was employed.

The filling was of three kinds:

(a) Clean river sand.
(b) Gravel.
(c) Garden soil.

and the values of the coefficient of friction and the angle of repose for each class of material were first determined.

A description and illustrations of the apparatus used, which was along the lines of the rotating board, were given. The method of measuring the magnitude of the resultant moment of the earth pressure was by observing the extension of a bar fitted with a Ewing extensometer. The movement of the material and therefore all "arching" effect was consequently reduced to a minimum.

The rotating board and apparatus were so arranged that the conditions could be made to approximate to the cases of a wall with its inner face vertical or battered inward or outward.

The operation of filling was carried out on a system described, and measurements of the moment were made with the materials at various heights, and also with and without a surcharge loading. The total height without surcharge was limited to 7 ft., and with surcharge it reached 9 ft.

An indication is given briefly of the foundation on which the theories are based, and the methods by which the general formulas derived from them have been evolved.

It is also shown in what respects the Rankine and wedge theories agree and differ, and reference is made to the direction of the resultant pressure.

The values of the overturning moment for the case of a vertical wall with no surcharge, as obtained experimentally, and those calculated from the derived formulas, are given in a table and illustrated by curves. The Rankine figures where the direction of the resultant pressure is taken as parallel to the surface of the filling are greatly in excess of the observed values, while those obtained from the wedge theory approximate fairly closely to experiment.

For inclined positions of the rotating board representing walls battered inwards and outwards, the experimental and calculated values are tabulated in other tables, and are also illustrated by curves. These indicate that calculations based on the wedge theory give results in accordance with experiment at the lower levels and in fair agreement at the higher. With the wall inclined inward the Rankine figures are about 50 per cent in excess, but owing to the fact that they vary very little in the three positions taken, they agree more closely, though still in excess, when the wall is inclined outward.

Coming to the case of surcharged walls, it is pointed out that the equations founded on the theories mentioned apply only to unlimited planes of surcharge, and as it was necessary to limit the height to which the filling was carried in the experiments as in ordinary practice, a modification of the wedge formula was made. The calculated results obtained from this modified formula are contrasted with those got by the use of the Rankine and wedge formulas for a continuous and unlimited surcharge, in tables, and are also illustrated by a series of curves.

With the board vertical the modified formula gives rather low values at the lower level, but agrees fairly well at the higher with experiment. The wedge and Rankine formulas for unlimited slope give values too great by 20 per cent and 50 per cent, respectively.

The experimental values obtained with the board inclined inward fall below in the sand tests, especially at the lower level, what might be expected, but this is considered to be due to some accidental cause. Otherwise, agreements is maintained between the moment calculated from the modified formula and experiment. With the unlimited-slope formulas the calculated values are about 40 per cent in excess.

Corresponding agreement exists in the case of the board inclined outward, the unlimited slope calculated values showing an excess of about 50 per cent.

Viewing the whole series of experiments the greatest discrepancy occurred with the 7-ft. levels (no surcharge) when gravel filling was used, and was worst with the board inclined outward. Low experimental values were also obtained in the sand tests at the lower level under surcharge.

The results of the experiments may be said to justify the following conclusions:

1. That the overturning moment on retaining walls due to the filling, as calculated from a general formula based on the wedge theory, is approximately the same as ordinarily exists when the filling behind the wall is uncompacted, when the height is within the limits of these experiments, and when the inclination of the inner face of the wall either outward or inward is not greater than usually obtains in practice.

From this it would follow that the following assumptions which were made may be taken as warranted:

(a) That the resultant pressure on a unit length of wall makes an angle equal to the angle of repose with the normal to the wall.

(b) That the position of the resultant pressure is at a point on the inner face distant one-third from the bottom of the wall.

2. That in the case of walls with a filling whose surcharge is not continuous and unlimited, the general formula requires modification. This can be done by reducing the sliding prism of irregular section to one equivalent triangular section from which the overturning moment can be deduced either by direct calculation or by a convenient graphical method.

The position of the resultant pressure may under these conditions range from 0.33 to 0.364 of the inner face of the wall measured from its base.

The Capitalist, the Inventor and the Research Laboratory

From Engineering, London, Jan. 9, 1920.

The inventors and organizers of British industry were brought to light and to high-pressure activity by the patent laws and the laws encouraging commercial enterprise and securing its fruits to the enterprising. Hardly anyone would seriously dispute this. Practically all the men engaged in running our industries would go further, and say that if the patent laws and the laws protecting private property were repealed, inventive and organizing talent would cease to be manifest in anything like the same degree as at present. At the same time, however, they themselves are unfortunately pursuing a policy which negatives the effect of the patent laws in encouraging invention, while complaining bitterly of the accumulation of legislation and taxation which limit the reward of organizing effort. Just as the Socialists look upon the rewards of the organizer as undue and a burden upon the community, so the organizers look upon the rewards of the inventor as undue and a burden upon their businesses, and seek to diminish them.

The lot of the inventor has always been hard, unless he was exceptionally placed, and combined commercial with inventive ability. But in two ways it is getting increasingly difficult. As technology advances, experiment becomes much more costly, and at the same time the protection afforded by the patent laws becomes less and less. Powerful interests with unlimited capital to draw upon can fight the inventor's rights with an ever-increasing mass of technical and patent literature to draw upon on disproof of novelty. Combination between manufacturers renders it more and more difficult to find anyone who is willing to back a new thing which fills an old want already filled by existing devices. Nevertheless, the essential importance of invention from the national point of view is now recognized, and research laboratories are being set up which are to afford every facility for experiment. The success of this movement depends upon getting the inventors into the laboratories, and upon their doing their best work when they are there. In fact, the problem has a psychological aspect of the first importance.

There is one more or less obvious solution. Assure to the inventor as good a reward as a man coming from outside with the same invention would obtain, and you are sure of him. The growing handicap upon individual effort would be made good. This policy, generally pursued, would result in an enormous stimulus to inventive activity. This solution does not seem likely of adoption. Men entering these laboratories are being required to sign away all rights of every kind to any invention they make make. They are to rely solely upon a reward at the discretion of the firm. A great many arguments are brought forward to defend this course, mostly of an ethical nature. It is also attacked on other grounds, with equal vigor and plausibility. Probably its real basis is as follows: The business man regards anyone to whom he pays a regular salary as an employe, and he regards the time during which the employe is working for him as his own, or the firm's. It seems to him altogether inadmissible that the employe should retain any absolute rights of property over work done in that time. In any case, he feels that the employe inventor has risked nothing of his own in working out the invention, as an outside inventor has done. Finally, he is possibly in many cases relying upon the increasing difficulties which beset independent inventors to drive them into his fold upon terms favorable to himself.

There are men working under extreme difficulties all over the country, struggling to get money for experiment and patent fees. There are others of equal ability but more sense, who see that the game is not worth the candle, and that there are surer roads to fortune. The terms offered may bring in a few of the disheartened, but they will be seeking a haven. The rest will struggle on as before, or turn to other things. The independence of intellect essential as an attribute of the inventor is usually coupled with an independence of character which leads to his feeling the signing away of his rights to be a confession of weakness. The research laboratories, on the other hand, will easily fill their vacancies with university graduates; men with most respectable records of "original" papers and laborious tests; but those who feel the least spark of original genius will not readily forego their freedom.

Apart from the genius, however, any young man of ability considers his prospects. In management, he has both patent freedom and the prospect of lucrative and commanding positions. On the other hand, the man entering a research laboratory has no promotion in the ordinary sense to look forward to and work for. Not all men with a taste for invention and experiment are erratic geniuses unfitted for big managerial positions; but the latter require to be filled by men who have graduated by experience in management, and the research worker renounces this training, and with it the prizes. All he has in exchange is a vague promise of reward at his employer's discretion.

One solution of the problem is, perhaps, worthy of detailed consideration, namely, that a research laboratory should be an independent organization, financed by the parent firm, but receiving royalties on a liberal scale to be divided among its members by agreement among themselves according to the share of each in the work done, after interest on the capital lent by the firm and other legitimate expenses incurred have been paid. One might possibly go so far as to demand the payment of all experimental expenses out of royalties, though the usual patent agreement with outside inventors does not as a rule go on these lines. Disputes in the research laboratory as to division might be referred to an arbitrator. It may be useless to put forward such a scheme. The British business man is already much aggrieved that he is less and less "master in his own house." But he must either realize beforehand or else find out by experience, that he will never get first class research done by men who are regarded as mere employes and who have not full inducements to exercise their brains in carrying out the inquiries they have in hand.

The Largest Concrete Blocks.—In his presidential address, read before the Institution of Civil Engineers on Nov. 4, Sir John Purser-Griffith referred to the complete success which had followed the use of what are claimed to be the largest concrete blocks ever used. These blocks each contained more than 5,000 cu. ft. of masonry and weighed about 350 tons. They were used in the construction of the North Quay extension of the Port of Dublin. The blocks were built above high-water level and when sufficiently set were lifted by a floating shears or crane and deposited on a bed prepared by steam dredging; they were leveled by men working in a large diving bell, entered through a tube fitted with an air lock. The same floating plant was used for laying similar large blocks for breakwater protection, and for the foundation of one of the lighthouses at the entrance of the harbor. These great blocks were designed by the late Dr. Bindon Blood Storey, F.R.S., M.Inst.C.E., the engineer of the Dublin Port and Docks Board, and for the work for which they were specially designed they proved a complete success, both from a structural and economic point of view. By their use it was possible to build the extension quays without costly cofferdams or heavy pumping.—Concrete and Constructional Engineering.

The Resistance of Concrete to Repeated Blows. Crushing and tensile strength tests are excellent for judging the comparative values of Portland cement and concrete for ordinary building purposes, but if these materials are to be used under conditions where they will be subjected to repeated blows or vibrations a third test should be added. Dr. Passow worked out an elaborate investigation in order to determine the value of a test in which a cube of the material of 2¾-in. sides is subjected to a large number of blows applied by a miniature pile-driver. At the same time he investigated the minimum height from which a weight must be dropped on a block of cement mortar or concrete in order to crack it at the first blow. These experiments showed that resistance to blows depends more on the elasticity and toughness of the aggregate and on the hardening period than on the cement, provided enough cement is used to form a suitable binder. Curiously enough, whilst the crushing and tensile strengths increased with the age of materials, its resistance to blows decreased.

There appears to be no definite relationship between either the crushing or tensile strength and the resistance of the material to a falling weight.—Beton und Eisen.

Road and Street Monthly Issue

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Roads and Streets—1st Wednesday
(a) Roads (c) Street Cleaning
(b) Streets (d) Municipal Miscellanies
(e) Management and Office System

Waterworks and Hydraulics—2nd Wednesday
(a) Waterworks (c) Irrigation and Drainage
(b) Sewers and Sanitation (d) Power and Pumping
(e) Management and Office System

Railways and Excavation—3rd Wednesday
(a) Excavation (c) Quarries and Pits
(b) Management and Office System (d) Steam Railways, Construction and Maintenance
(e) Electric Railway Construction and Maintenance

Buildings and Structures—4th Wednesday
(a) Buildings (d) Miscellaneous Structures
(b) Bridges (e) Properties of Materials
(c) Harbor Structures (f) Management and Office System

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Articles on Logic to Be Resumed

Publication of the series of articles on logic by Mr. Gillette will soon be resumed. The writing of these articles was temporarily suspended pending the preparation of an article on the causes that affect the average prices of commodities. That article has been completed and appears in this issue.

Although it is not an article on logic, it may serve as an exemplification of quantitative reasoning applied to a subject that has hitherto resisted complete quantitative analysis.

Quantitative Versus Qualitative Thinking

We have repeatedly pointed out that no exact solution of any economic problem is possible until a quantitative value is assigned to every factor that materially affects the result. Herbert Hoover recently wrote a letter that was read at the annual convention of the Society of Industrial Engineers. He said:

"I do not think too much emphasis possibly can be laid on the necessity of engineers taking an active interest in public affairs. Theirs is an education and an experience in quantitative thinking and acting, and our country generally needs quantitative, as distinguished from qualitative, thinking on its great industrial and business problems."

Few economic questions are of greater importance at present than those that relate to high costs. Editorials without number have been written upon this subject, but the arguments and even the data given in most of the editorials have been erroneous. Again we have witnessed the futility of attempts to solve an economic problem without correct quantitative data correctly applied.

It has been held that very complex economic problems, such as those relating to changes in average prices, can not be solved by engineering methods—that is by quantitative methods. We have been told that so many variables enter as factors that mathematical logic can not be used in solving such problems. But the writer is not of those that are always ready to cry "impossible." He believes that the word "impossible" more often is a camouflage for ignorance than a sound excuse for the existence of ignorance. Acting upon this belief, he has spent several months trying to deduce a formula for estimating relative wholesale prices (or index prices) of commodities. The results of this study are embodied in the article which will be found on page 381 of this issue of Engineering and Contracting. This article contains his deduction of a wholesale price formula, together with proof of its substantial accuracy when applied to each of the past 60 years.

28 Pages=40 pages

The 28 pages of articles in Engineering and Contracting contain as many words as 40 pages of the size and typography commonly used by other engineering periodicals. Ours is the same size of type and type-page as that of The Literary Digest—easily read, yet giving a large volume of reading matter per page. Our 28 pages of articles would fill 112 pages of the standard 6x9 in. text-book. It would take 10 such books of 580 pages each to hold all the articles printed each year in Engineering and Contracting, to say nothing of our weekly construction news.

Should Road Construction Be Halted

There has been a tendency to reject bids for highway construction on the ground that prices will be lower next year. Engineers and others who expect lower construction prices should read the article that begins on the following page. The facts there given make it certain that construction prices lower than those of 1919 can not be expected for many years.

If the facts and the reasoning in that article are substantially correct, no necessary public works should be halted in the hope of securing lower prices. Least of all should roadwork be halted, for the profit derivable from better roads is annually so great as to make it imperative that improved roads be built as rapidly as practicable.

What Ohio Cities Are Doing in City Planning

In a paper presented Jan. 21 before the Ohio Engineering Society Prof. F. H. Eno of Ohio State University outlined, as follows, the progress being made by Ohio municipalities in city planning work:

Akron has a commission on city planning of 7 members, which was organized in 1916. Since that time more than 4,000 acres of subdivided property had been passed upon and approved by the commission. Plans had been prepared for widening 14 streets. A comprehensive plan of the city with reference to its future development had been prepared by John Nolan, the noted city planner. At the last election Akron voted a $650,000 bond issue for the widening of Market St., also $3,000,000 for the extension of street pavements. The accurate checking of all measurements upon all plats and subdivisions submitted for approval had been another activity of the commission.

Canton has a commission which is now considering the zoning of that city. They have had to turn down three allotment plans because the plans failed to meet the proper requirements of the commission.

Cincinnati has a commission of 7 members which has completed plans for improving sewers, transportation and parks for a greater Cincinnati. They are being supported by a federated city plan committee from 18 different civic organizations who are planning with the commission, methods for securing money to launch out on the work.

Cleveland has a city planning commission composed of 6 men from the city administration and 5 citizens. It began service in 1914. In 1916 $16,000 was appropriated to begin surveys and plans for a greater Cleveland. This sum has been increased each year since. The commission has two advisers, one a home man and the other from the East. They have purchased land for a mall 570 ft. wide and 1,970 ft. long at a cost of $1,107,000. Around this are to be grouped the city hall, county court house, federal building, library, auditorium, a county-city criminal building and a union station, with other public buildings, such as the chamber of commerce, society for savings building, the East Ohio Gas building and others yet to come. Of those named, all are built or building except the library and the union station, of the public buildings. The land and 6 public buildings have cost, or have bond issues now outstanding for completing them, totaling more than $21,000,000.

Dayton has a commission composed of the city manager and 3 citizens, who have established rules regulating size of lots, width of roadways, controlling allotments, etc. They have prepared plans for a civic center somewhat similar to the plans proposed for Columbus some 10 years ago by an outside commission.

Hamilton has a commission of 7 members organized July 16, 1919. They have engaged a landscape architect of St. Louis, to direct the work of the planning commission. They have prepared and expected to have a zoning law in operation in Hamilton by January, 1920.

Lorain has no planning commission but the chamber of commerce, with 1,200 members, has a plank in their "boost Lorain plans" calling for such a commission.

Toledo has a commission of 5 men. They have plans for a civic center around a court house and have already purchased some land for it.

Method of Determining Points on Highway Vertical Curves

To the Editor: In your issue of March 3 you publish a letter from Mr. S. L. Moyer explaining a rule of thumb method of determining points on highway vertical curves. Although mentioned as being approximately a circle, this curve proves to be the common parabola, a fact which Mr. Moyer seems to have overlooked. It is the same curve as that for which Mr. J. A. Lilly furnished formulas and tables in your issue of Feb. 4. The axis of the parabola is vertical and the vertex is at the highest (or lowest) point on the curve, no matter what the rates of grade or whether the grades are in the same or opposite direction. Also, the curve is tangent to the grades at points A and B. The only approximation is the usual one existing between a circle and parabola with the same tangents, and the difference in elevations is very small.

This method of laying out a parabola is a new one to the writer, but probably it is an old time favorite among men who have used it on certain classes of work. However, it does not provide an easy means of finding the elevations at other than the middle, quarter, eighth, etc., points of the curve, and for such work the scheme followed on railroad work would be preferable. This method, with some variations and explanations, formed the substance of a letter from the present writer which was published in Engineering and Contracting on June 7, 1916, to which reference is made here for the convenience of those who wish to make a further practical study of one of the uses of this curve.

Mr. Moyer's method of handling the parabola would be a very convenient plan for laying out flat horizontal curves on highways, even though the plans call for true circles. As is well known to all who have had to line up curves during construction, there are more mules than stakes on the job at the critical time, and delays are costly and aggravating. In this case the straight lines of one edge of the pavement could be extended to an intersection and then known or assumed equal tangent distances measured off. The intermediate points could next be located by subdividing and making middle ordinates and externals equal to each other, all measurements in this later work being made parallel and perpendicular to the long chord. This method would give good results on curves ot any length so long as the central angle is small. As a trial case, a curve of 300 ft. radius and a 30 degree central angle, in which the tangent distance is a little over 80 ft., can be laid out as a parabola with an error of a trifle more than 2 in. at the center and less elsewhere. When the central angle is 20 degrees the error is less than 1 in. unless the length of curve is more than 250 ft. Such accuracy should warrant the use of this method.

In the sketch of Mr. Lilly's letter there is an unfortunate discrepancy in the drawing of the vertical lines which makes them appear as though intended to be inclined. It should be remembered that the distances are measured with a horizontal tape and the elevations with a vertical rod. Then the true parabola will result and also the mid-point of the long chord will be directly below the intersection of grades.

New Rochelle, N. Y. LEONARD C. JORDAN.

Water Supply for Concrete Road Construction.—In providing a water supply the essential requisites are continuous service, ample supply and good pressure. Dual pumping plants are the best insurance for a continuous service, according to a paper presented by Mr. Richard Hopkins at the recent convention of the American Road Builders' Association. Where there is a point of high elevation near the road, a storage tank of 1,500 to 3,000-gal. capacity is also a big help. Ample supply and good pressure cannot be maintained with a small pipe line. The 1½-in. pipe should be used only on short lines with a heavy gravity head. The 2-in. pipe line is in almost universal use and is satisfactory where the line does not exceed one mile in length. Much better results on the average job will be obtained with a 2½-in. pipe line, states Mr. Hopkins. Its use will become increasingly popular as construction men begin to appreciate how many of their pumping troubles disappear when this larger line is put in service. Where sources of supply are a long distance apart, booster pumps are necessary to provide good pressure.

Quantitative Analysis of All Factors That Affect Average Prices and a Formula for Predicting Price Changes

By HALBERT P. GILLETTE, Editor.

Lest the title of this article give an impression that it is either very "theoretical" or "mathematical," let it be known that it is highly "practical" and that an understanding of it involves no more knowledge of mathematics than is required to solve the simplest problems in arithmetic.

As to the practical nature of the article, the reader may judge by the fact that it aims to answer the following questions:

1. What are the causes of present high prices?
2. When will prices begin to drop?
3. How rapidly will they drop?
4. How far will they drop?
5. Are American workmen as efficient now as in the past?
6. What has been their productive efficiency during the past 60 years?
7. Do bank deposits (or credit currency) have any effect on average prices, and to what extent?
8. Does the quantity of currency in circulation affect prices, and to what extent?
9. Can average prices be lowered by economizing in personal expenditures?
10. Does an increase in population affect prices, and to what extent?
11. Is the rapidity of "turnover" of money readily ascertainable?
12. Does the rapidity of "turnover" affect average prices, and to what extent?
13. Is it possible to produce a simple rule or formula for estimating average prices accurately?
14. If such a rule or formula is now available, why has it never been deduced before?
15. How can such a rule or formula be demonstrated to be correct beyond any question?
16. Is it wise to lay in a large stock of goods or supplies now?
17. Is it wise to construct buildings, public works, etc., now?
18. Can bankers safely lend money on buildings erected at present prices?

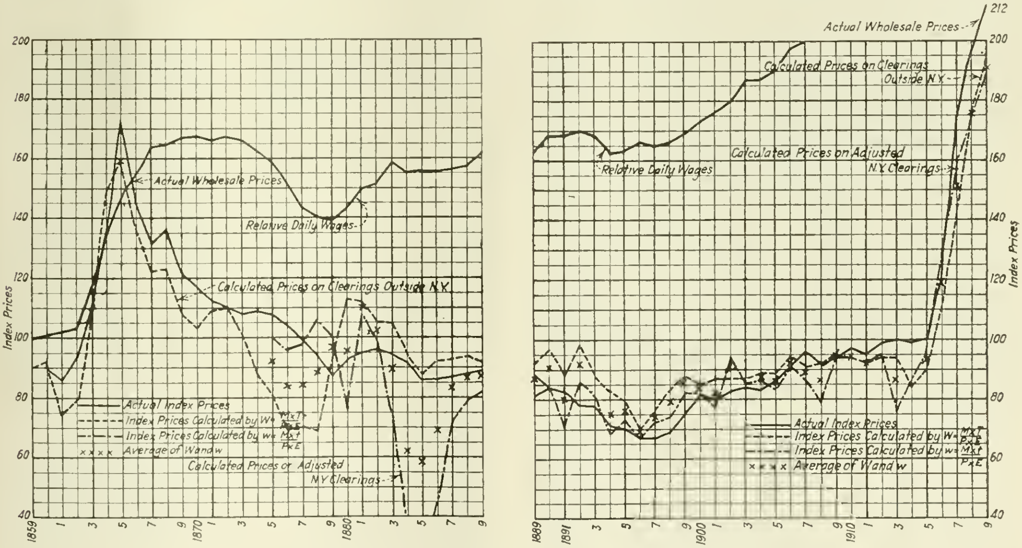


Fig. 1—Wholesale Index Prices of Commodities, Actual and Calculated.

19. Will average wages rise to a much higher level?

20. Will the costs of operating and maintaining railways and public utilities decrease so rapidly in the next few years that the present rates of charge for their service will then suffice?

Formidable as this array of questions looks, every question will receive a definite and, I trust, convincing answer. To be convincing, the answers must be based on facts that are not subject to dispute—facts that anyone can verify. Moreover, there must be some way of testing the accuracy of the deductions. In the world of science, every new "law" or formula is always put to the test of observation or experiment before it is regarded as being trustworthy. Since my rule or formula for estimating average prices is based upon scientific data, it must be submitted to tests as to its reliability before it can be presumed to be scientifically correct. The results of these "tests" will be given in detail, so that the reader may form his own conclusions as to the trustworthiness of the formula or rule. The reader, therefore, will be asked to accept nothing on faith and nothing on deductions not verified by tests.

Should the reader ask how a rule for predicting future prices can be tested until the "future" has become "present," the reply is that a correct rule or formula enables us to "predict" the past. My formula can be applied to any given year in the past 60 years, and its results will be found to agree very closely with the relative average wholesale price (or "index prices") of the given year. For example, suppose the reader were to ask me what the average wholesale index price of commodities was in 1903, according to the index of prices published by the Bureau of Labor, taking the year 1913 as 100 per cent. Applying my formula, the reply is 86, or that the average wholesale price in 1903 was 86 per cent of that in 1913. This result is arrived at according to the formula and the reader may test it by turning to the actual index price published by the Bureau of Labor (see Table I) which he finds to be 84 for the year 1903. Since the actual price index of 84 differs by only 2 points, or less than 3 per cent from the price calculated by my formula, it becomes evident that the formula has enabled us to predict the past with considerable accuracy for that particular year. If, in a similar manner, the reader finds that, with the formula, he can quite accurately "predict" the prices of the past for every year from 1859 to 1919, despite a range from 67 for 1896 to 212 for 1919, he must concede that the formula should be reasonably reliable for predicting average prices of the not too distant future.

Let us see how closely the results obtained by the formula agree with the actual relative wholesale prices of commodities ("index prices") for each of the past 60 years. To do this turn to Table I. The last two columns in that table gives the actual "index prices" for each year. The footnote of the table gives the sources of my information.

Columns A, B and C of Table I give the calculated "index prices" using my formula. Column C is the average of columns A and B, and is ordinarily to be preferred, for reasons that will be given later; but for the years 1876 to 1878, and 1884 to 1886 column A is more reliable. The data relating to the last 30 years are more reliable than for the first 30 years, hence we may expect closer agreement between the calculated "index prices" and the actual "index prices" between 1889 and 1919, than between 1859 and 1889, and it will be seen that this is the case.

To any engineer, and in fact to any professional or business man who is accustomed to the use of quantitative data in reasoning, it will be apparent that my formula must be substantially correct, for were it not, it could not possibly yield results that agree so closely with the facts for every year over a period of 60 years, particularly when the wide range of average prices during that period is considered. Moreover, the range of the factors that are used in my formula is also very great. Population is 3.5 times what it was, per capita currency is 3.2 times what it was, per capita bank deposits are 6.2 times what they were in 1859, and the per capita productive output of commodities has doubled. All these are factors in my price formula. It is therefore incredible that the price formula would give substantially correct results for every year since 1859, when the factors in the formula vary over such a wide range, unless the formula contains substantially all the factors that affect average commodity prices, and at the same time gives to each of the factors its proper "weight."

To those readers who are accustomed to the use of graphical expression of quantitative relations, the price "curves" in Fig. 1 will be even more convincing than the corresponding numbers in Table I. Fig. 1 will be explained later, but a glance at it shows how closely is the agreement between the "curve" of actual "index prices" and the "curves" of index prices calculated by the aid of my price formula.

When it is seen that my formula does not contain certain factors that are commonly supposed to affect the average price level, this article should not be cast aside in the belief that its author must be wrong. Let it be remembered that hitherto there has been much disagreement among economists and business men as to what the factors are that affect price levels; hence that it is unwise not to study carefully and completely all the arguments pro and con. Especially is this a wise procedure when the arguments are supported by quantitative data.

Many bankers and teachers of political economy will be inclined to reject my formula at first sight, because they will not see in it certain factors that they will expect to see. I appeal to them to hold in suspense their judgment until they have finished reading this article.

Many business men will also be inclined to reject the formula, when they first see it. Some of these men will do so because they will confuse "relative average wholesale prices" with the relative wholesale prices of certain commodities with which they are familiar. They are apt to do this because there is a tendency to confuse the price level of a certain few commodities with the price level of all commodities. Similarly when they read that the per capita efficiency of production in America was practically the same in 1919 as in 1913, many manufacturers, contractors and business men will be apt to doubt the accuracy of my statement. But if this article is read carefully to the finish, I think that all such doubts will vanish, for the data that will be presented will carry conviction.

This rather long preamble has seemed necessary in order to prevent impatient readers from casting aside an article that purports to tell how to accomplish what is seemingly impossible. So eminent an economist as Wesley C. Mitchell has recently said that more than 20 factors would have to be

TABLE I—WEIGHTED WHOLESALE INDEX PRICES OF COMMODITIES.

Year.	Calculated by Gillette Formula, using: Clearings outside of N. Y.	Adjusted N. Y. clearings.	Total U. S. clearings adjusted.	Actual: Bureau of Labor, and Aldrich report.†	Actual: Dun's.‡
1859	90	..	...	90	...
1860	92	..	...	90	96
1861	74		...	86	85
1862	79		...	93	98
1863	106	.	...	110	144
1864	149			135	232
1865	159		...	172	161
1866	135	.	..	144	173
1867	122		..	131	156
1868	123	..	..	136	152
1869	107	.	..	122	137
1870	103		.	117	123
1871	109	...	..	112	126
1872	110	.	...	110	125
1873	102	...	...	108	119
1874	88	...	...	109	119
1875	81	100	92	108	112
1876	69*	96	83	104	97
1877	70*	98	84	99	91
1878	69*	106	88	93	80
1879	93	101	97	87	81
1880	113	77	95	93	90
1881	112	108	110	95	93
1882	105	99	102	96	102
1883	105	72	89	94	89
1884	94	34*	64	92	83
1885	88	27*	58	86	75
1886	92	46*	69	86	74
1887	93	72	83	87	78
1888	94	79	87	88	79
1889	92	82	87	89	74
1890	97	84	91	84	76
1891	88	71	80	83	80
1892	99	86	93	78	75
1893	88	81	85	78	75
1894	82	68	75	71	69
1895	80	73	77	70	68
1896	70	67	69	67	62
1897	76	72	74	67	60
1898	84	74	79	69	61
1899	88	82	85	75	72
1900	85	82	84	82	78
1901	87	77	82	80	80
1902	87	94	90	83	83
1903	87	85	86	84	82
1904	89	86	87	83	83
1905	89	83	86	86	84
1906	95	91	93	91	87
1907	91	86	89	96	93
1908	92	79	86	91	91
1909	95	94	95	94	98
1910	94	94	94	97	99
1911	92	92	92	95	97
1912	94	95	95	99	103
1913	94	76	85	100	100
1914	84	87	86	99	101
1915	90	96	93	100	105
1916	110	128	119	123	124
1917	113	158	151	175	169
1918	177	174	176	196	190
1919	194	190	192	212	192

Foot notes.

*Abnormally low.

†The actual index prices are those derived from two sources: (1) From 1859 to 1889, the index prices are those given in Senate Report No. 1394 on "Wholesale Prices, Wages and Transportation." by Nelson W. Aldrich, March 3, 1893. The weighted average index prices there given are multiplied by 0.9 to reduce them to the same base as the index prices, of the U. S. Bureau of Labor, the latter index prices being those from 1890 to 1919, using the year 1913 as 100. The Aldrich report index prices are based on the wholesale prices of 223 commodities, weighted in proportion to family budget expenses. The Bureau of Labor index prices are based on the wholesale prices of 192 commodities in 1890, as given in Bulletin No. 173, and in the Monthly Labor Review, December, 1919, and January, 1920.

‡If the index prices given in Dun's (Mercantile Agency) Review are multiplied by 0.83 they will be reduced to the same base (the year 1913 being taken at 100) as that used in this table. Dun's index prices are the weighted average of 300 wholesale quotations on commodities (the weighing being in proportion to annual production). The quotations are taken for the first day of each month, and the resulting index prices for each of the 12 months are added together and divided by 12 to give the figures that appear in the last column of this table for every year from 1898 to 1919, inclusive; but prior to 1898 Dun gives index prices only for Jan. 1 and July 1, of each year. The numbers given in the last column of this table from 1860 to 1897, inclusive, are the index prices on July 1. Index prices on July 1 are ordinarily quite close to the average for the entire year. In not a single year since 1898 have Dun's index prices for July 1 differed by more than 4 per cent from the average for the 12 months; but for the years 1863 to 1869, it seems evident that Dun's index prices for July 1 (which are those given in the table) are not typical of the entire year.

analyzed before a reliable deduction of index prices could be attempted. In the War Industries Price Bulletin No. 1, the statistician of the Board, Mr. Mitchell, said:

> An adequate discussion of the controverted question: What controls the fluctuations of the general level of prices? would require the compilation and analysis of a vast amount of data in addition to the material contained in these bulletins. Statistics of gold stocks and gold movements; bank notes, bank deposits, and bank reserves; railway and marine freights, retail prices, wages, interest rates, real-estate prices, security prices; the volume of speculation and of trade in commodities; the amount of Government loans, "capital issue" by corporations and savings—all these matters would have to be canvassed, and at that the list is incomplete. Nor could the fundamental changes brought by the war in the organization and control of industry, marketing, transportation, and methods of finance be left out of account. The investigation would have to extend to foreign countries, because the course of American prices was profoundly affected by the earlier and more rapid rise in Europe. This history of prices during the war contains an indispensable part of the materials needed to treat this general problem, but it contains only a part. To add the rest of the materials and analyze them would delay unduly the appearance of data needed as a basis for action. The theoretical question of broadest interest is therefore put aside. Fortunately, private investigators may be trusted to attack this problem when the fundamental data are made available to them.

Mr. Mitchell evidently had in mind the attempts made by Prof. E. W. Kemmerer, professor of political science and economics at Princeton University, and by Professor Irving Fisher, professor of political economy at Yale. I will speak later of their pioneer work in this field. At the present, I need only say that neither Professor Kemmerer nor Professor Fisher deduced a formula for determining index prices of commodities, but that their formulas merely purported to give results that were a weighted average of index prices of commodities, of railway shares and of wages—a sort of composite price trend. The complexity of their methods may be judged by the fact that each of them wrote a book to explain and justify his formulas.

In contrast with that complexity, my method involves the use of only five variable factors, the data for every one of which can be found in the Statistical Abstract of the U. S. Census, or in the files of such periodicals as the "Financial Chronicle." Indeed, with the aid of the data in this article, supplemented by the statistics published in the large daily papers, the reader can predict the general levels of average prices with considerable accuracy for several years in the future. I do not say that he can thus predict the price trend of any single commodity. That is another and more difficult problem.

Index Prices.—Before a correct understanding of the present subject can be secured, the meaning of certain terms must be learned. One of the most important of these terms is the expression "index price." Its technical sound, however, merely camouflages a very simple thing, namely, a relative average price.

"Index numbers" are relative numbers in which data for one year (or longer period) are taken as a base of 100, or 100 per cent,and upon which data for other years are computed as percentages. When the index numbers relate to prices, they are called "index prices." Thus, if the year 1913 is taken as the base year, and average wholesale prices of, say, 300 commodities are taken, that average may be called 100 per cent. Then if the average wholesale price of the same 300 commodities is 1.96 times as high in 1918 as in 1913, the index price for 1918 is 196, or 196 per cent of the average price in 1913.

To take a simple illustration, let us assume that the wholesale index price of the four principal cereals is desired for the years 1914 and 1918. From the U. S. Statistical Abstract for 1918, we find that the average wholesale prices (on the farm) were as follows per bushel:

	1914.	1918.
Corn	$0.65	$1.37
Wheat	0.99	2.37
Oats	0.44	0.71
Barley	0.55	0.92
Simple average price	$0.658	$1.343

If we add the prices of these four grains and divide by four, we get a "simple average price" of $0.658 for the year 1914, and $1.343 for the year 1918. Hence, if we take the year 1914 as our standard year, we get $1.34 ÷ $0.66 = 203 as the index price for the year 1918, when the corresponding index price is 100 for the year 1914.

This method of calculating index prices does not take into consideration the relative quantities of each of these four cereals produced in the given years. To give the proper "weight" to the quantities produced, the calculation of "weighted average prices" must be made as follows:

For the year 1914:

Corn	2,673,000,000	bu.	at	$0.65	=	$1,737,450,000
Wheat	891,000,000	bu.	at	0.99	=	882,090,000
Oats	1,141,000,000	bu.	at	0.44	=	502,040,000
Barley	195,000,000	bu.	at	0.55	=	107,250,000
Total	4,900,000,000	bu.	at	$0.659	=	$3,228,830,000

Dividing the total of $3,228,830,000 by 4,900,000,000, we get $0.659 as the "weighted average unit price" of these four cereals in 1914, as compared with the "simple (or unweighted) average price" of $0.658 previously deduced.

A similar calculation for 1918 is as follows:

Corn	2,583,000,000	bu.	at	$1.37	=	$3,538,710,000
Wheat	917,000,000	bu.	at	2.37	=	2,173,290 000
Oats	1,538,000,000	bu.	at	0.71	=	1,091,980,000
Barley	256,000,000	bu.	at	0.92	=	235,520 000
Total	5,294,000,000	bu.	at	$1.330	—	$7,039,500,000

This gives a "weighted average unit price" of $1.330 for these four grains, as compared with the "simple average price" of $1.343.

Now if we divide the weighted average price of $1.330 (for the year 1918) by that of $0.659 (for the year 1914), we get 202, which is the weighted index price of these four cereals in 1918, as compared with weighted average index price of 100 for the year 1914.

Where several hundred commodities are thus treated, the weighted index prices do not usually differ greatly from the unweighted index prices, but the smaller the number of commodities thus grouped to secure an average price, the greater the range of differences between weighted and unweighted index prices. Hence, it is always preferable to use weighted index prices when they are ascertainable.

In selecting the total annual quantities to be used for each commodity, the choice usually lies between the total quantity produced during the year, or the total quantity consumed in the households. The first of these two is obviously to be preferred, unless the object is to ascertain the relative living expenses of the average family in different years. Since, in the long run, the average family pays its share of nearly all expenditures made in a nation, it follows that the weighted average index price of all commodities produced annually is the best single standard by which to reduce incomes and expenses to a basis that makes one period truly comparable with another.

Figure 1 and Table I show the weighted wholesale index price in the United States for every year from 1859 to 1919, the year 1913 being taken as 100 per cent. From 1890 to 1919, the index prices are those of the U. S. Bureau of Labor. Back of that they are those of the Aldrich Report of the Senate Finance Committee made in 1893. The Aldrich index prices were weighted in proportion to the average family expenditures, whereas the Bureau of Labor prices were weighted in proportion to production of commodities.

In using Fig. 1, as an example take year 1911 and follow the straight line up till it intersects with the heavy black line. From the point of intersection follow the straight line to the left and note that it reads 95, which is the average wholesale index price for the year 1911. Similarly for any other year; 1918, for example, shows an index price of 196. In other words, average wholesale prices were 96 per cent higher in 1918 than in 1913, and they were 5 per cent lower in 1911 than in 1913.

Figure 1 shows the change in average wholesale prices for every year since 1859. Note the sudden and great rise of prices that occurred in the four years of our civil war, 1861 to 1865 (average prices rose 91 per cent). Note the sudden drop in prices in 1866 (prices dropped 16 per cent). Then observe that there was a much less rapid decline thereafter, but that the pre-war price level was not reached again until 1878, 13 years after the war ended. From 1865 till 1896, average prices descended quite uniformly (except for 1866 and 1867); then there came a turn in 1897 and prices rose steadily until 1915, when they shot skyward, rising 112 per cent in four years.

Observe, also, that average prices dropped 28 points, or 16 per cent in 1866 compared with 1865, the year the civil war ended. Contrast this with the rise of 14 points, or 7 per cent, that occurred in 1919 compared with 1918, the year the world war ended. History has evidently not repeated itself in respect of an immediate price decline following a war. The reason for this will be very clear when we come to the discussion of the formula for predicting relative average prices, or index prices.

The Writer's Price Formula.—Before deducing my formula for calculating wholesale index prices, or relative wholesale prices, I will state the formula and discuss its economic significance.

Expressed verbally, the formula is: The wholesale index price for any given year varies directly with the total amount of currency in circulation and with the average number of times it is turned over annually, but it varies inversely with the total population and the per capita efficiency of production.

Expressing this as a mathematical formula, we have:

$$W = \frac{K \times M \times V}{P \times E}$$

W stands for the index price for any given year.

K stands for a constant quantity that depends upon the index price scale and upon the year selected as a base of 100 per cent for E. As will be shown later, K = 0.5.

M stands for total money or "currency in circulation" in the United States as of July 1st of the given year.

V stands for relative rapidity of money turnover (or "velocity of circulation").

P stands for total population of the United States for the given year.

E stands for per capita productive efficiency. This will be discussed very fully later.

Before deducing my price formula, it seems wise to discuss the significance of each of its factors, M, V, P and E.

The Effect of Money on Prices.—Near the beginning of the third century, Julius Paulus, speaking of money (nummus), said:

> Eaque materia forma publica percussa, usum dominiumque non tam ex substantia praebet, quam ex quantitate. ("Pandects", II, Book XVIII, 147.)

Translated this means:

> And this tangible public money having been affected would buy less of public goods (or services) and pay less taxes, not so much because of its (lessened) intrinsic worth, but because of its (excessive) quantity.

John Locke, the English philosopher, wrote the following 229 years ago:

> The value of money, in general, is the quantity of all money in the world in proportion to all trade; but the value of money in any one country, is the present quantity of the current money in that country, in proportion to the present trade. (Locke's Works, V. 49.)

Nearly 170 years ago, David Hume said:

> It seems a maxim almost self-evident, that the prices of everything depend on the proportion between commodities and money, and that any considerable alteration in either has the same effect, either of heightening or lowering the price. (Hume's Essay on "Money" in "Essays Moral, Political and Literary," I. 316.)

Almost every political economist of note has observed that a sudden and marked increase of money has been accompanied by an increase in prices.

Ricardo wrote:

> That commodities would rise or fall, in proportion to the increase or diminution of money, I assume as a fact which is incontrovertable.

Later political economists, notably John Stuart Mill, began to qualify such generalizations. Mill said:

> The value of money, other things being the same, varies inversely as its quantity; every increase of quantity lowering the value, and every diminution raising it, in a ratio exactly equivalent. This . . . is a property peculiar to money. . . . In a state of commerce in which much credit is habitually given, general prices at any moment depend much more upon the state of credit than upon the quantity of money. (Mill's "Principles of Political Economy," II. 30, 53.)

Mill, it will be seen, fell into the error of assuming that "credit" has a marked effect on prices, and nearly every political economist has followed him in this error. A noteworthy exception was the late Professor Francis A. Walker. He said:

> The quantity-theory of money is simply an expression, with reference to a special case, of the general law that value is determined in the relation between demand and supply. Prices being nothing more or less than values expressed in terms of money, those who hold the quantity-theory merely point out a specific instance for the application of a principle which has been established by competent induction, and the applicability of which is not challenged in any other instance within the view of the political economist. (Francis A. Walker's "Discussions in Economics and Statistics," I. 211; also 193-236.)

But it could not be denied that there were many instances of change in money supply that were not accompanied or followed by equal changes in average prices.

Professor Simon Newcomb then introduced the factor of "velocity of circulation" (V), or what I have called the rapidity of money turnover. This seemed to be a difficult factor to measure, and, so long as it was not measurable, it served no practical purpose. Professor Newcomb also recognized that the volume of commodities produced annually was a factor that affected average prices, but this also seemed difficult to measure.

Professor E. W. Kemmerer, now of Princeton, in 1907 published a book on "Money and Credit Instruments in Their Relation to Prices." In that book he made the first attempt to measure "velocity of circulation" and volume of trade for a series of years. But he also fell into the error of believing that checking deposits in banks have the same effect as currency. Moreover, he failed to see that the per capita efficiency of production should enter the formula as a separate factor and should not be hidden in the composite total called volume of trade. Nor did he recognize the necessity for excluding the effect of dealings in stocks and bonds.

Professor Irving Fisher, in his "Purchasing Power of Money" (1911), followed very closely the precedent established by Professor Kemmerer. His later book, "Why the Dollar Is Shrinking" (1914), is a brief and popular discussion of the subject matter of his earlier book.

In common with other eminent political economists, Professor Fisher and Professor Kemmerer agree that changes in the volume of currency tend to effect changes in average commodity prices. There is virtual unanimity among economists on that point, but occasionally some one who has not studied the available data has voiced an opinion to the contrary. For example, it was recently said by an English writer that "inert money could not affect prices of commodities," because that would be tantamount to affrming that the human mind does not control the demand for things and that "inert money" does. This argument has a plausible sound, but it fails to take account of the fact that the human mind not only registers its demand for commodities in terms of money, but that the average man is habituated to spend practically all his income every year. Moreover, the small part that he does not spend himself he turns over to other men to spend, receiving in return interest or dividends for the "use" of his money. Borrowed and invested money can be effectively used only by spending it. The parable of the money that was wrapped in a napkin and laid away illustrates this fact splendidly.

Since practically all the money in a nation is turned over several times annually in purchasing all the commodities that are produced and imported, it follows that the total quantity of the money in circulation must affect commodity prices. It is also evident that, although "inert money" can not create a demand of itself, "money burns a hole in the pocket" of nearly everyone that has it. This holds as true of the capitalist as of the laborer, the one spending money (all that he has and all that he can borrow) to make more money, the other spending it mostly for living expenses and luxuries. The point is that practically all the annual income is spent every year and that, in the final analysis, it is spent for commodities.

The presence of "inert money" does not leave the human mind inert, but rouses the desire to spend it or to lend it to those who will spend it. One might as well say that the mere presence of an inert dish of luscious strawberries could not cause the average hungry man to eat, as to assert that inert money can not cause a desire to spend it and thus register a demand for commodities.

My formula for wholesale index prices is:

$$W = \frac{M \times V}{2 \times P \times E}$$

From this formula, it follows that a given percentage increase in money increases average wholesale commodity prices an equal percentage, provided the other factors remain unchanged. In the past it has been customary to ridicule such a statement by saying that the other factors never remain unchanged, hence, that it is useless to assume that they do. This sort of criticism usually comes from men who have never studied even the elements of the science of forces.

No change occurs in this universe except as the result of the interaction of two or more forces. When no change occurs the interacting forces still exist, but they are opposing one another in such a way as to produce an equilibrium. Thus, a book lying on a table tends to fall to the earth, because the force of gravity is constantly pulling it downward. That it does not fall is due to the existence of another force acting with equal pressure upward, namely, the force of elasticity in the table. Substitute a spring balance for the table, and the eye perceives at once the quantitative "strength" of elasticity registered in pounds. If the spring that supports the book is severed, the book falls with increasing velocity, because gravitation is now acting without opposition, save the slight resistance of the air. Similarly, we may say, if the volume of money is steadily increasing, average commodity prices will increase at an equal rate, provided no other forces are acting to retard or to accelerate the increase. But the formula shows that there are other forces acting upon average comdity prices, namely, the forces whose pull is quantitatively measured by V (rapidity of turnover of money), P (total population) and E (per capita productive efficiency).

There are certain years in which V, P and E have remained practically unchanged, whereas M has changed considerably. Thus, on July 1, 1919, money (M) had increased about 8 per cent over the quantity in circulation on July 1, 1918 (See Table II), whereas population increased only about 1 per cent and rate of money turnover (V) and productive efficiency (E) remained practically constant. Hence, the increase of 8 per cent in money (M) would be expected to raise prices 8 per cent, whereas the increase of 1 per cent in population would lower prices 1 per cent, and the net effect would be a rise of 7 per cent in prices. Turning to Table 1 and Fig. 1, we see that prices actually rose 16 points or 8 per cent between the average for 1918 and the average for 1919.

When a scientific reasoner attacks a problem involving the analysis of the effect of several interacting forces, he often pictures to himself what would happen were only one of the forces changing while the rest remain unchanged. This is all that I mean when I say: "Other things being equal a change in the volume of money will cause an equal change in average wholesale prices." But men who have studied neither logic nor the physical sciences (mechanics in particular) are prone to ridicule such a statement, because they do not understand its full significance.

Professor Kemmerer gives an excellent illustration of how scientists and engineers solved the problem of determining the path of a shell or bullet, and therefore the place it will strike under given conditions. First, the trajectory (or path) is calculated from Newton's laws of gravitation and the elementary principles of mechanics, assuming that there is no air to resist the projectile. An ignoramus would at once interpose by saying: "That is nonsense. There is air, so why assume there isn't any." But the engineer would reply: "Wait a moment. I am allowing for a few forces at a time. I will come to the resistance of the air later."

Having calculated the path of the projectile, assuming its entire flight to be in a vacuum, an engineer would next assume the effect of the resistance of still air of uniform density. Having calculated the effect of this factor, he would next assume the air to be of density progressively decreasing with the height from the earth, and calculate the effect of that change. Finally, he would assume the existence of a wind, varying in intensity and in direction, and deduce its effect upon the path of the projectile. Then, having deduced a general formula that would give proper quantitative weight to each of the factors (or forces), he would be able to predict with considerable accuracy where a projectile would hit.

Now, this is exactly what engineers have done in evolving a theory of gunnery that enables them to direct gunfire, often with marvelous accuracy. Consider, for example, that the great German gun that bombarded Paris was 76 miles from Paris (almost as far as from Philadelphia to New York), and that the shell rose to a height of 24 miles in its flight, yet that 60 per cent of the 303 shells fired at Paris landed within the city limits. The target was actually large, but considering that it was at a distance of 76 miles, it was a relatively small target. Moreover, it was an invisible target. Also, bear in mind that this very long range gunnery was entirely in the experimental stage. It was an outrage thus to experiment on a target inhabited by noncombatants, but I give this as a spectacular illustration of the accuracy of mechanical science, even when some of the interacting forces cannot be exactly measured and when the "machinery" is experimental and undeveloped.

The Probable Changes in Money Supply.—In order to forecast the trend of commodity prices, the probable change in currency in circulation must be determined within reasonable limits. The total currency in the United States on July 1, 1918, was about 5,379 millions, and on July 1, 1919, it was 5,841 millions of dollars, an increase of 8 per cent. On December 31, 1919, it was 5,960 millions, or an increase of 2 per cent in the last six months of 1919. Apparently, the rapid increase in our money supply came to an end about the middle of 1919. In 1919, our gold stock decreased nearly 10 per cent, but this was nearly offset by an increase in paper money.

In 1918, Great Britain and her provinces and colonies produced about 249 million dollars of gold, the United States produced about 69 millions, and the rest of the world produced about 62 millions. Half the gold produced ordinarily is used in the "arts," for jewelry, etc. At this rate, about 190 millions of dollars of gold were added to the money stock of the world in 1918. All told, this is barely more than 3 per cent of the total currency in circulation in America December 31, 1919, so that if we were to get and retain it all, it would tend to raise our average commodity prices about 3 per cent. There is small likelihood that we shall get and retain all the gold added annually to the money supply of the world.

There are about 9,000 millions of dollars in gold in the whole world in use as money, and America has nearly one-third of this total. Our war allies owe this nation more than 9,000 million dollars, not to mention what they owe to American firms individually. Certainly Europe can not pay us its entire debt in gold, nor should we permit them to pay even a small fraction of it in gold, even if they wished to do so. They need the little gold they have as a basis for their top-heavy paper currency. Our war allies increased their currency 180 per cent during the war by the issue of paper money. Whereupon the average prices of their commodities rose almost the same percentage, being now nearly 2.8 times what they were in 1913.

Every European nation engaged in the war made the blunder of printing paper money, thus inflating prices. On December 31, 1914, America's stock of gold was 1,816 million dollars; it rose to 3,081 millions in the following four years, and on December 31, 1919, it was 2,788 millions. In their futile attempt to pay us in gold, our war allies have sent us gold that has served to upset all our price and wage schedules. Yet nearly all bankers and business men continue to welcome the arrival of more gold from Europe as if it were an economic blessing, instead of the economic curse that it really is. The more we add to our money, the higher will commodity prices raise or the slower they will descend.

Fortunately, for us, Europe can not send us much more gold annually without great danger to her own monetary and credit system. However, it is reported that England and France are planning to pay America 500 million dollars in gold the latter part of 1920. If that is done it will add another 8 per cent to our total stock of currency in circulation, and average commodity prices will rise another 8 per cent, unless the relative rate of money turnover (V) or productive efficiency (E) change sufficiently to offset the effect of an 8 per cent increase in money (M).

There is very little probability, in any event, that the total currency in circulation in America will decrease appreciably for many years. If it does not decrease, there will be no lowering of average prices of commodities attributable to a change in currency. Hence practically all hope of lower prices must be found in changes in the other three factors in my price formula. Let us next consider the factor, V, the relative rate of money turnover.

Measuring the Rapidity of "Money Turnover."—Everyone is aware that when "business is good," bills are paid more promptly than when it is "poor." A little consideration of this fact makes it clear that "money is turned over" more rapidly in "good times" than in "bad times." It is also known that average prices of commodities rise in "good times." It follows from these two facts that there is a relationship between the rapidity of "money turnover" and average prices of commodities. Yet relatively few men, even among the educated, know that there is a direct quantitative relationship between average prices of commodities and rapidity of money turnover. Failure to appreciate this important economic fact is mainly due to the lack, in past years, of a simple method of measuring the rapidity of "money turnover." I have devised a simple, reliable method of measuring the relative rate of "money turnover" (V), which any man can readily use. But before discussing this method, let us consider the meaning and significance of two terms: (1) Bank clearings and (2) bank deposits. The discussion of these factors is necessarily somewhat long, because relatively few men, even among bankers, have a complete understanding of the economic significance of statistics relating to the total deposits in all banks and the total bank clearings.

TABLE II—POPULATION, CURRENCY AND BANK DEPOSITS.

Year.	Population (June 1).	Currency per capita.	Bank deposits per capita (July 1).	Total bank deposits† (millions).
1859	30,822,000	$14.35	$35.80*	$1,098*
1860	31,443,321	13.85	34.60*	1,089*
1861	32,064,000	13.98	35.00*	1,121*
1862	32,704,000	10.23	25.60*	837*
1863	33,365,000	17.84	44.50*	1,488*
1864	34,016,000	19.67	49.20*	1,674*
1865	34,748,000	20.58	51.50*	1,787*
1866	35,469,000	18.99	47.50*	1,684*
1867	36,211,000	18.29	45.70*	1,655*
1868	36,973,000	18.42	46.00*	1,702*
1869	37,756,000	17.63	44.10*	1,664*
1870	38,558,371	17.51	43.80*	1,691*
1871	39,555,000	18.17	45.40*	1,797*
1872	40,596,009	18.27	47.50*	1,928*
1873	41,677,000	18.09	48.80*	2,035*
1874	42,796,000	18.13	50.80*	2,173*
1875	43,951,000	17.16	49.66	2,183†
1876	45,137,000	16.12	47.65	2,151
1877	46,353,000	15.58	44.38	2,057
1878	47,598,000	15.32	39.94	1,901
1879	48,866,000	16.75	37.53	1,834
1880	50,155,783	19.41	42.55	2,134
1881	51,316,000	21.71	49.47	2,539
1882	52,495,000	22.37	52.49	2,756
1883	53,693,000	22.93	54.80	2,876
1884	54,911,000	22.65	52.40	2,874
1885	56,148,000	23.03	54.50	3,061
1886	57,404,000	21.78	55.50	3,186
1887	58,680,000	22.45	56.32	3,596
1888	59,974,000	22.88	57.01	3,704
1889	61,289,000	22.52	61.62	4,025
1890	62,947,714	22.82	64.51	1,361
1891	63,844,000	23.45	65.74	4,482
1892	65,086,000	24.60	71.67	4,944
1893	66,349,000	24.06	69.74	4,834
1894	67,632,000	24.56	68.77	1,849
1895	68,934,000	23.24	71.39	5,167
1896	70,254,000	21.41	70.39	5,122
1897	71,592,000	22.92	71.16	5,245
1898	72,947,000	25.19	77.98	5,874
1899	74,318,000	25.62	91.08	6,964
1900	75,994,575	26.93	95.26	7,527
1901	77,612,569	27.98	109.01	8,817
1902	79,230,563	28.43	114.91	9,501
1903	80,848,557	29.42	118.17	9,953
1904	82,466,551	30.77	121.27	10,288
1905	84,084,545	31.08	134.99	11,735
1906	85,702,533	32.32	142.54	12,546
1907	87,320,529	32.22	150.02	13,553
1908	88,938,527	34.72	143.75	13,166
1909	90,556,521	34.93	155.79	14,687
1910	92,174,515	34.33	165.81	15,658
1911	93,792,509	34.20	169.59	16,332
1912	95,410,503	34.34	178.43	17,480
1913	97,028,497	34.56	180.10	17,905
1914	98,646,491	34.35	187.72	18,955
1915	100,264,485	35.44	191.75	19,628
1916	101,882,479	39.29	224.55	23,319
1917	103,500,473	45.74	254.01	26,776
1918	105,118,467	50.81	265.72	28,511
1919	106,740,000	54.74	309.89	33,065

Footnotes:

*Estimated by multiplying total currency by 2.5 for the years 1859 to 1871, inclusive, then by 2.6 for 1872, by 2.7 for 1873, and 2.8 for 1874.

†For years following 1874 the data given in the Statistical Abstract of the U. S. (1918) are taken, except as to private banks, which (since 188[illegible]) have been estimated by multiplying the private bank deposits given in the Statistical Abstract by 4, because only one-fourth of the private banks have reported their deposits. The correctness of this estimate for private banks is confirmed by data given in Mitchell's "Business Cycles." The total deposits in private banks has been only about 3 per cent of the total deposits in all other banks for several years past.

Some business men know that the ratio of the total bank clearings of a given year to the average bank deposits during that year, is roughly indicative of the "activity of business." But they also know that there is so great a speculative trade in stocks, bonds, grains, etc., that bank clearings often increase or decrease much more rapidly than the general business of the country increases or decreases.

In seeking for a simple means of measuring the relative rapidity of "money turnover," I felt at the start of my study of this problm that it should be practicable to eliminate most, if not all, of the effect of speculative transactions upon bank clearings. My first step, therefore, was to take the bank clearings outside of New York City as being a better barometer of trade than the bank clearings in New York City. When I divided the annual bank clearings outside of New York by the total bank deposits in the United States at the middle of any year, I found that the quotient was usually about 4.5 in years when business was "normal," that is, when there was neither a "boom" nor a "depression."

This result encouraged me in the belief that I might be able to "adjust" the New York bank clearings, so as to eliminate the effect of stock and bond sales. I reasoned that in the case of an outright purchase of stock, a stock broker would deposit the check or draft received from his client, and would draw his own check for an almost equal amount payable to the person from whom the securities had been purchased. Hence there would appear in New York bank clearings $2 for every $1 of outright sales of stocks. In case of a purchase "on margin," a similar result would follow, because the broker would borrow from his bank the difference between the "margin" put up by his client and the purchase price of the stock.

Acting upon this theory, I deducted from the New York bank clearings twice the stock and bond sales for each year, from 1893 to 1919, and I found that the remainder was almost exactly equal to the bank clearings outside of New York City, every year. This is well shown in Fig. 2, which is convincing evidence that my method of eliminating the effect of stock and bond sales from New York bank clearings is substantially correct. Back of 1893, there were difficulties in applying this method, but I overcame all of them ultimately, as will be explained later.

Since the New York bank clearings "adjusted" as just described are substantially equal to the bank clearings outside of New York, either one, or a combination of both, may be used in my price formula to measure the rapidity of "money turnover."

In case the combination of the two is used, my price formula is:

$$W = \frac{M \times V}{2 \times P \times E}$$

But if we use outside New York clearings, the formula is:

$$W = \frac{M \times T}{P \times E}$$

And if we use "adjusted" New York clearings, the formula is

$$W = \frac{M \times t}{P \times E}$$

In these formulas

$$V = \frac{K}{D} = \frac{C + c}{D}$$

$$T = \frac{C}{D}$$

$$t = \frac{c}{D}$$

V stands for relative rate of "money turnover" (or "velocity of exchange") for any given year, using the total bank clearings (K) "adjusted" by deducting the effect of New York stock exchange transactions.

T stands for relative rate of "money turnover," using bank clearings outside of New York (C).

t stands for relative rate of "money turnover," using "adjusted" New York clearings (c).

D stands for total bank deposits in the United States at the middle of the given year.

"Bank clearings" is a term that denotes the total value of checks and drafts sent to the clearing houses. The total annual bank clearings in America constitute about 40 per cent of the total checks drawn. It is evidently immaterial what this ratio is (whether 40 per cent or some other percentage), so long as it is fairly constant; for my values of V, T, and t are purely relative, and any constant factor disappears where a ratio is involved.

If great precision in the use of my price formula is sought, there are other speculative transactions whose effect should be deducted from bank clearings, such as bank clearings due to the sales of grain and cotton on the "exchanges," and the sales of securities on stock exchanges other than the New York stock exchange. But fortunately only a very small percentage of the speculative transactions in grains and cotton result in the drawing of bank checks, which is quite different in this respect from speculative transactions in stock and bond sales on the New York Stock Echange. The transactions of other stock exchanges are relatively small, and have been so for many years. Thus, in 1893, there were ten times as many shares of stock sold on the New York Stock Exchange as on the Boston Stock Exchange; in 1916 the ratio was 18 to 1; and in 1919 it was 40 to 1. The Chicago Stock Exchange sales are approximately the same as those of Boston. Hence I have not found it necessary to do more than eliminate the effect of New York Stock Exchange sales.

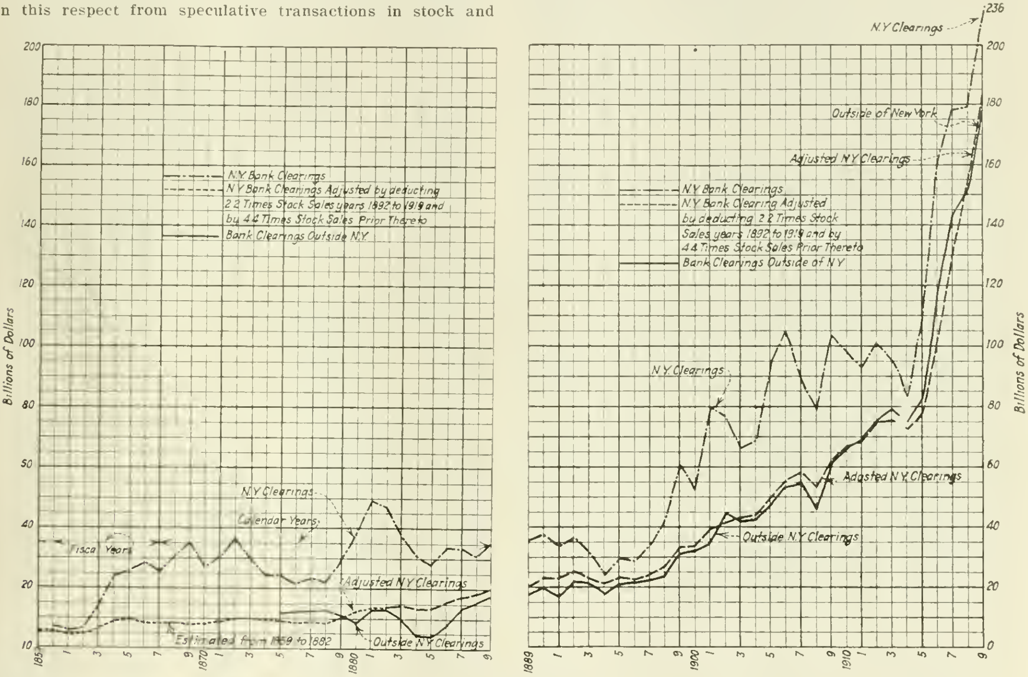


Fig. 2—Bank Clearings.

Modern political economists (with very few exceptions) have hitherto held that bank deposits against which checks may be drawn (often called "credit currency") are essentially the same as money, and that, therefore, an increase in bank deposits tends to raise the level of prices just as does an increase in money. It will be observed that my formula does not support that belief, unless it can be shown to be a fact that bank deposits subject to check have increased in the same proportion that money has increased. Figure 3 and Table II both show that the ratio of bank deposits to total currency was 2.2 to 1 in the year 1880, and that it rose to 5.7 to 1 in 1919. The rise was steady and so rapid during those 40 years as to make it clear that, had total bank deposits had the same effect as currency in raising prices, there would have occurred a price increase several fold in excess of what actually did occur. Table VI shows that the ratio of total bank deposits to deposits subject to check has been constant for 30 years, so that it cannot be contended that the more rapid increase in total bank deposits has been offset by a decrease in the proportion of checking deposits to total deposits.

There remains only one other way in which the increase in total bank deposits could be offset, and that would be by a decrease in the rapidity of turnover of checking deposits. This, however, has not occurred. Prof. Fisher states that the contrary has occurred. But we need not use his estimates to prove this contention, for all that is necessary is to refer to Tables V and VI. In Table V we see that the ratio of bank deposits to total bank clearings "adjusted" for the effect of New York Stock Exchange transactions has averaged about 9 for the past 30 years, oscillating back and forth for this average. Table VI shows that during the same period the ratio of total deposits to checking deposits has averaged 2 to 1, and that there have been only slight departures from this average at any time. Hence it follows that the ratio of "adjusted" annual bank clearings to checking bank deposits (="credit currency") has averaged 18 to 1, and that there have been only relatively small departures from this average.

It is made clear from these facts that the rapid increase in bank deposits, as compared with the less rapid increase in total currency, has not been offset either by (1) a decrease in the ratio of checking deposits to total deposits or by (2) a decrease in the rapidity of annual turnover of checking deposits. This being so, it is conclusively established that average commodity prices would be nearly two times as high as they now are, were it a fact that checking deposits have the same effect as currency upon prices, it being remembered that per capita bank deposits have increased 2 times as rapidly as currency since 1890 (See Table II).

To me this fact is a complete refutation of the prevailing theory that "credit currency" (="checking deposits") is the same in its effect as currency, but since this theory is very strongly rooted, it seems wise to devote some more space to its refutation. I trust that the reader will be patient in following this discussion, and I believe that he will if he considers the immense importance of securing a correct conception of what factors affect average price, and to what extent.

It is a very plausible argument to say that, since bank checks serve the same purpose as currency, therefore an inflation of bank deposits has the same effect as an inflation of currency in raising the prices of commodities. But the argument is fallacious. Currency deposited in a bank serves two distinct purposes:

1. A part of the currency thus deposited serves as a reserve that takes the place of money in business transactions, and

2. A part of the currency thus deposited serves as a reserve to insure the credits extended to patrons of the bank in the form of loans.

It is this second function that has not been hitherto given proper consideration in reasoning about the causes that affect the prices of commodities.

Prior to the great modern development of banks as credit insurance agencies, manufacturers and merchants secured most of their credit from the people from whom they purchased goods. Gradually, however, banks began to lend more credit to business men, thus enabling them to pay their bills more promptly and secure discounts for prompt payment. What happened was merely a transfer of credits from the ledgers of merchants and manufacturers to the ledgers of bankers. A credit given by a bank to a patron becomes a bank deposit, and when he checks against it, his check is deposited by the payee, thus maintaining the same total of bank deposits.

In 1875 bank deposits were about $50 per capita, when currency was $17 per capita (See Table II). In 1919 bank deposits were $310 per capita, when currency was $55 per capita. Hence bank deposits were 6.2 times as great per capita in 1919 as in 1875, whereas currency was only 3.2 times as great. In other words, per capita bank deposits increased nearly twice as rapidly as currency increased during those 44 years. This indicates approximately the rate at which banks have been growing as credit lenders or credit insurers.

Now, a transfer of a dollar of credit from the ledger of a merchant to the ledger of a bank certainly has no effect upon commodity prices. Credit in either case merely postpones the day of payment, and postponing the day of payment has no effect upon prices, provided the payment interval remains unchanged. For example, if a wholesale merchant were giving a 90-day credit to a retail merchant and if they were doing a constant amount of business monthly, the first of every month the retailer would pay for the goods purchased three months previously. A continuation of this practice would evidently have no effect whatever upon commodity prices, were all merchants pursuing the same methods. Suppose a bank were to "lend money" to the retail merchant so that he would need no credit whatever from the wholesale merchant, then the retail merchant would pay the wholesaler "spot cash" every month, but he would also pay the banker once a month, taking up the note given 90 days previously. Clearly, then, the credit given to the retail merchant by the banker would merely supplant the credit given by the wholesale merchant. The effect would be to increase bank deposits but it would not alter the total credits that had previously existed. No limited time credit, whether it be that given by a wholesaler or that given by a bank, affects the total normal demand for goods. Credit thus given causes fluctuations from normal in the demand, which affects the rate of money turnover (the V in my price formula), but, otherwise, limited time credits have no affect on the average price of commodities.

It was this reasoning that led me to use only currency (M) in my price formula. I did not first derive the formula by "cut and try," or empirical methods. I deduced it from the principles of business economics. Then I applied it to past years and proved that my reasoning had been correct, because the formula gives index prices that agree substantially with the actual index prices.

The loaning of credit by banks is possible because currency held as a bank reserve is more efficient than currency in circulation outside of banks. This well known economic fact needs no discussion. If one dollar in a bank reserve serves the purpose of, say, four dollars in circulation outside the banks and if half the total dollars in circulation are held as bank reserves, it would appear that the result of depositing half the total currency in banks would be to increase the total buying power to 2.5 times what it had been. Thus, if two billion dollars of currency are in circulation and then one billion dollars are deposited and held as bank reserves, and if each dollar in a bank reserve does the work of four dollars in circulation outside, then there would be the equivalent of four billion plus the outside one billion, or a total of five billion, which is 2.5 times the original two billion. And this is exactly what would happen were it not that all of the three bilions of dollars thus virtually "created" are employed to "insure" the credit transactions above mentioned. In other words, of the one billion dollars placed in the bank reserves, three-quarters of a billion is used as a credit insurance fund, whereas one-quarter of a billion is used as a reserve to take the place of the one billion of currency that formerly circulated outside the banks.

Failure to see this distinction between the two uses of bank reserves accounts mainly for the fact that hitherto there has not existed a formula for calculating index prices of commodities. Once I had perceived the distinction, the problem of deriving a practical formula was greatly simplified.

It remains to reply to those who will contend that the currency in circulation could not possibly handle the total volume of business were there no banks. Take the year 1910, for example, when the total currency in circulation was 3,102 million dollars, and the total bank clearings were 163,722 millions (See Table IV). Here is a ratio of 1 to 53, so that the currency would have to be turned over oftener than once a week to transact such a business. Furthermore, there are about

TABLE III—NEW YORK AND BOSTON STOCK EXCHANGE SALES.

	New York			Boston.
Calendar year.	No of shares of stock.	Stock value in millions.	Bonds at par in mililons.	No. of shares of stock.
1860				
1861				
1862				
1863				
1864				
1865	[1], [4]10,461,296			
1866	23,811,183			
1867	21,211,036			
1868	19,713,402			
1869	10,513,058			
1870				
1871				
1872	[2]54,861,300			
1873	[2]42,982,400			
1874				
1875	[3]53,813,937	$ 2,863		
1876	39,926,990	2,133		
1877	49,832,960	2,602		
1878	39,875,593	2,158		
1879	72,765,762	4,137	$ 571	
1880	97,919,099	6,820	644	
1881	114,511,248	8,198	486	
1882	116,307,271	7,690	293	
1883	97,049,909	6,261	314	
1884	96,154,971	5,940	527	
1885	92,538,947	5,480	682	
1886	100,802,050	5,886	649	
1887	84,914,616	4,509	374	
1888	65,179,106	3,540	353	
1889	72,014,600	4,060	398	
1890	71,282,885	3,978	379	
1891	69,031,689	3,813	391	
1892	85,875,092	4,875	503	
1893	80,977,839	4,551	301	8,105,838
1894	49,075,032	3,095	355	6,397,130
1895	66,583,232	3,809	503	8,910,219
1896	54,654,096	3,330	386	7,385,210
1897	77,324,172	4,974	545	11,485,668
1898	112,699,957	8,188	918	13,056,920
1899	176,421,135	13,430	768	17,181,334
1900	138,380,184	9,250	645	8,016,109
1901	265,944,659	20,432	917	15,458,270
1902	188,503,403	14,219	951	9,872,774
1903	161,102,101	11,005	596	10,064,145
1904	187,312,065	12,062	1,037	11,920,208
1905	263,081,156	21,296	1,022	15,982,372
1906	284,298,010	23,394	672	17,705,338
1907	196,438,824	14,758	519	14,114,125
1908	197,206,346	15,320	1,052	12,967,418
1909	214,632,194	19,143	1,293	15,503,336
1910	164,051,061	14,126	634	11,638,965
1911	127,208,258	11,004	897	7,159,139
1912	131,128,425	11,563	670	[5]11,158,661
1913	83,470,693	7,171	494	5,635,533
1914	47,900,568	3,899	456	[5]3,524,161
1915	173,145,203	12,662	961	12,598,951
1916	233,311,993	18,870	1,150	13,130,314
1917	185,628,948	15,610	1,047	5,111,472
1918	144,118,469	12,483	1,980	3,892,890
1919	316,787,725	25,905	3,809	8,639,863

Foot Notes:

[1] Last 6 months only. Bond sales totaled 11,879. The total sale price of the stocks and bonds was $821,000,000.

[2] Only 27 leading stocks.

[3] Total sale price $2,862,903,683, or $53.20 a share, which was a very low average due to the panic of 1873.

[4] Between April, 1864, and April, 1865, there was a heavy decline in railway stock, prices having become badly inflated during the war. For example, New York Central Ry. stock sold at 69 to 92 in 1860, 68 to 82 in 1861, 80 to 108 in 1862, 107 to 140 in 1863, 109 to 145 in 1864, 83 to 119 in 1865

[5] Boston exchange was closed from July 31 to Dec. 10, 1914.

$2.50 of bank checks deposited for every dollar that appears in bank clearings, so that, it will be argued, the ratio of total checks deposited to total currency would be fully 130 to 1, indicating a turnover about once every three days. This looks very formidable, and on its face appears to discredit any theory that currency alone is capable of conducting the business of a modern nation. It is therefore necessary to explain this paradox.

When a bank "lends money," it "lends credit." It is in essence, a credit broker, using part of its patrons' currency as a reserve with which to insure the credits that it lends. When a retail merchant, for example, borrows $10,000 from his bank, he pays it back after he has sold $10,000 worth of goods. If all those goods were bought with bank checks payable to the merchant, he would deposit $10,000 in checks in his bank; then he would draw a $10,000 check to his bank in payment of the note he had given. This would result in $20,000 of checks deposited in his bank, whereas the actual commodities sold would be only $10,000. Since nearly all the checks deposited by the merchant would be on banks other than his, there would appear in the clearings of the local bank nearly $10,000. Evidently, then, the clearings in local banks are not so far below the volume of retail sales as would be assumed by the statement that checks deposited in local banks are usually several times the local bank clearings.

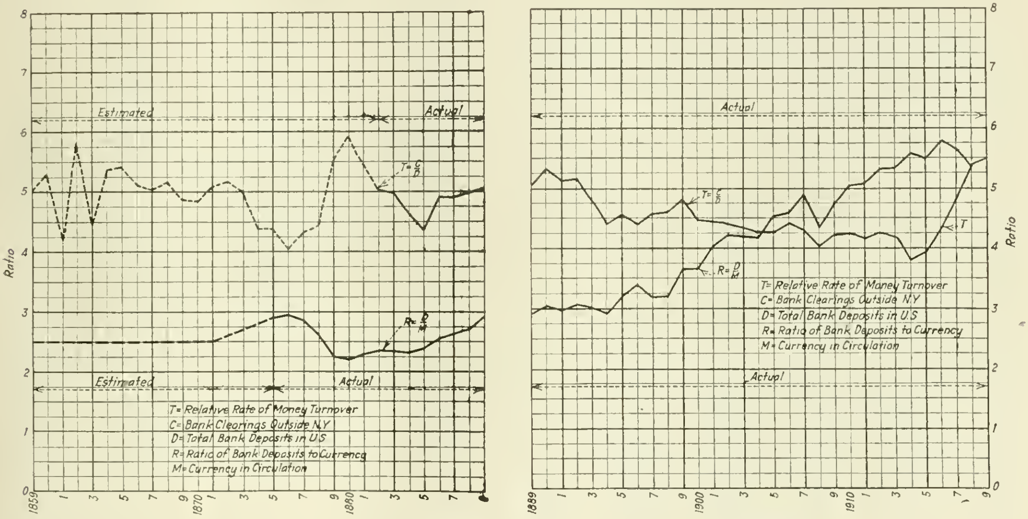


Fig. 3—Ratios of "Individual Bank Deposits" to Currency and to Clearings.

In 1910, the bank clearings in New York City were 102,500 million dollars, and for the rest of the United States they were only 67,000 million dollars. But, as I will show later, the New York clearings due to New York Stock Exchange transactions in 1910 were 36,000 million dollars, deducting which we have left 66,000 million dollars. The 36,000 million dollars of stock exchange transactions does not represent trade in commodities or services. It merely represents trade in securities which, for the most part, is pure gambling. To conduct this speculative trading, a relatively small amount of currency is needed. Roughly speaking, the entire business of the United States involved only 134,000 millions of bank clearings after eliminating the effect of New York Stock Exchange transactions. Half of this 134,000 millions was bank clearings outside of New York City. The other half was bank clearings in New York City after excluding the effect of stock exchange transactions; but only a small part of this half represents local business, most of the clearings being due to the practice of using the New York clearing house as a great central clearing agency for western checks and drafts on eastern cities. Many of the checks and drafts sent to New York City create clearings of $2 for each $1 of trade in merchandise for the reason above given. In the case of commission merchant or broker, a dollar check paid to him creates three dollars of checks deposited—the dollar that he receives, the dollar that he pays to his banker and the dollar that he pays to the manufacturer. It is safe to say, I believe, that not much more than half the 66,000 of New York clearings (exclusive of those due to stock and bond transactions) in 1910 represented a transfer of commodities. Hence, the total trade in commodities for 1910 in the United States was not more than 100,000 million dollars. Had the 3,100 million dollars of currency been used to conduct this trade, without the existence of banks, it would have had to turn over about 33 times in the year, or once every 10 days.

Professor Kemmerer has estimated that cash outside of banks is turned over about 47 times a year. Professor Fisher estimated the turnover at 22 times a year for cash outside of banks, and at 26 times for checking deposits in 1896 and 54 times in 1909.

Professor King ("Wealth and Income," p. 32) estimated the total income of the American people in 1909 at 30,500 million dollars, after excluding duplications, such as raw materials in manufacture. It is a matter of common knowledge that most commodities change hands three to four times before reaching the ultimate consumer. If we estimate 3.5 changes of ownerships and multiply by the 30,500 millions, estimated by Prof. King, we get 106,750 millions as the total trade in commodities in 1910, which checks well with my estimate of 100,000 millions which was arrived at in an entirely different way.

It is evident, therefore, that the total currency in the United States would be sufficient to conduct the entire trade in commodities, even were there no banks.

In this connection it should be pointed out that all payments for services eventually are used to pay for commodities. In other words, there is complete justification for equating all income to all commodities.

I have indicated how a portion of the currency held as bank reserves continue to "play the part" of currency outside of banks, but it remains to show why that portion of the currency in bank reserves remains a fairly constant percentage of the total reserves. Why, it will be asked, is not all the currency deposited in banks made to serve as a credit insurance fund? Or, taking the other extreme, why does any of it serve as such an insurance fund?

When the reserves of a bank are increased by the deposit of money, the banker is normally influenced thereby to increase his loans, for in no other way can he profit by such an increase in reserves. When, as a result of loans upon the new money, he has reduced his ratio of loans to reserves to the safe or legal limit, he ceases making further loans.

The money that has been removed from circulation outside of banks is replaced by bank check payments to an amount that equals the payments previously made with money; for custom as to the periods when payments are made with money is not easily changed. Thus, workmen are usually required to settle their grocery bills immediately after pay day. If certain workmen who have been previously paid in currency are given checks they cash the checks at once at some store, or at a bank, and then pay their bills. Even if the workmen open bank accounts, the effect is the same, for they draw checks that merely take the place of the money that they had formerly used in paying bills.

It is the fixity of custom as to the periods of payment for services of workmen, and a corresponding fixity of custom as to their payments for groceries, rent, etc., that renders inevitable the almost exact replacement of money by checks whenever money is retired from "outside" circulation and becomes part of bank reserves. This being so, it follows inevitably that practically all bank checks drawn in payment for commodities and services merely take the place of currency.

As a nation comes to use checks to an increasing extent instead of currency, an increasingly larger percantage of the currency finds its way into bank reserves; and each initial step of the process results merely in the substitution of checks for currency. Due to the greater efficiency of money used as bank reserves, the part of the money not needed for cashing checks immediately becomes an "insurance fund" against abnormally large demands for cash; and it is this part that is the reserve upon which bank loans are based.

Suppose there rapidly occurs an increase of, say, 10 per cent in the total "currency in circulation" (the money in bank reserves as well as that outside, but not in the government treasury). If all this increase at first finds its way into bank reserves, it will result in an increase in bank loans, which will immediately be followed by a bidding among the borrowers for commodities and services, thus forcing up prices. The end of the rise in prices and wages will not occur until the pre-existing ratio between circulating currency outside of banks and currency in bank reserves is established. This follows from the fact that it is the custom of a people to pay a certain proportion in cash and a certain proportion in checks. Hence any increase in currency soon distributes itself in accordance with this proportion. At present about half the total currency in circulation is in the hands of the people and half in the reserves of the banks; but it matters not what this proportion is, for if any added currency becomes distributed in the given proportion, it follows that it tends to increase prices in proportion to its ratio to the total currency in circulation. Coincidently, of course, bank deposits increase to a similar extent, because of the increase in bank reserves permits a corresponding increase in loans by banks.

TABLE IV—BANK CLEARINGS.

Year.	New York. (Millions.)	Philadelphia. (Millions.)	Boston. (Millions.)	Chicago. (Millions.)	All reporting cities in United States. (Millions.)
1859	....	$1,027	$1,444	......	....
1860	$ 7,232*	1,100	1,528	......	....
1861	5,916*	771	1,214	......	......
1862	6,872*	966	913	......	......
1863	14,868*	1,286	1,721	......	....
1864	24,098*	2,038	2,365	......	....
1865	26,033*	1,910	2,342	$ 309†	......
1866	28,718*	1,766	2,263	454	......
1867	25,811	1,641	1,866	581	......
1868	31,159	1,740	2,007	723	....
1869	35,541	1,856	2,124	734	......
1870	27,086	1,803	2,147	810	......
1871	30,643	2,165	2,392	868	......
1872	36,369	2,091	2,622	993	......
1873	29,840	2,189	2,667	1,047	......
1874	24,450	1,822	2,501	1,101	......
1875	24,313	1,833	2,502	1,212	......
1876	21,476	1,822	2,283	1,110	......
1877	23,860	1,522	2,336	1,044	......
1878	22,401	1,315	2,215	967	......
1879	29,235	2,027	2,674	1,257	$39,333[1]
1880	38,614	2,354	3,326	1,725	50,766
1881	49,376	2,716	4,233	2,249	64,282
1882	46,916	2,779	3,636	2,393	60,878
1883	37,451	2,812	3,515	2,517	51,731
1884	30,985	2,514	3,243	2,259	44,199
1885	28,152	2,374	3,483	2,318	41,474
1886	33 676	2,912	4,095	2,604	49,293
1887	33,474	3,194	4,387	2,969	51,147
1888	31,099	3,204	4,427	3,163	49,541
1889	35,895	3,645	4,772	3,379	56,175
1890	37,458	3,710	5,130	4,093	60,623
1891	33,749	3,296	4,753	4,456	56,718
1892	36,662	3,810	5,005	5,135	62,109
1893	31,261	3,403	4,577	4,676	54,323
1894	24,387	3,060	4,148	4,315	45,686
1895	29,841	3,556	4,757	4,614	53,348
1896	28,870	3,161	4,498	4,413	51,333
1897	33,427	3,222	5,095	4,575	57,403
1898	41,971	3,671	5,425	5,517	68,931
1899	60,761	4,811	7,086	6,612	94,178
1900	52,631	4,677	6,180	6,799	86,205
1901	79,420	5,475	7,191	7,756	118,579
1902	76,328	5,875	6,930	8,394	118,023
1903	65,970	5,847	6,717	8,755	109,209
1904	68,649	5,776	6,631	8,989	112,621
1905	93,822	6,928	7,655	10,141	143,909
1906	104,675	7,686	8,335	11,047	160,019
1907	87,182	7,161	8,135	12,087	145,175
1908	79,275	5,937	7,338	11,853	132,408
1909	103,588	7,021	8,440	13,781	165,608[2]
1910	97,275	7,690	8,299	13,939	163,722
1911	92,373	7,692	8,340	13,925	160,230
1912	100,474	8,166	8,964	15,380	174,914
1913	94,634	8,524	8,116	16,073	169,826
1914	83,019	7,916	7,517	15,692	155,242
1915	110,564	8,864	8,257	16,198	187,818
1916	159,581	13,083	10,757	20,541	260,953
1917	177,405	17,198	12,663	24,974	306,945
1918	178,533	19,717	15,637	25,930	332,354
1919	235,802	22,095	17,903	29,685	417,519

Foot note

*Fiscal year ending Sept. 30. †9 months only. [1]22 cities. [2]112 cities.

The bank clearings given in the Statistical Abstracts of the U. S. are for fiscal years ending Sept. 30. In ordinary times these do not differ greatly from those for calendar years ending Dec. 31, but in times of rapid business changes they may differ considerably.

TABLE V—RELATIVE RATES OF MONEY TURNOVER.

Year.	Outside N. Y. (T).	N. Y. after adjusting for stock exchange sales. (t).	All U. S. after adjusting for N. Y. stock exch. sales. V=T+t.
1859	5.00	....	....
1860	5.29	....	....
1861	4.12	....	....
1862	5.83	...	....
1863	4.40	...	....
1864	5.37	....	....
1865	5.40	...	...
1866	5.11	...	...
1867	5.01	..	....
1868	5.16	.	...
1869	4.85	..	....
1870	4.82	..	...
1871	5.06	.	....
1872	5.17	..	....
1873	4.98	...	...
1874	4.37	....	....
1875	4.36	5.37	9.73
1876	4.03	5.62	9.65
1877	4.32	6.01	10.33
1878	4.43	6.79	11.32
1879	5.54	6.02	11.56
1880	5.92	4.03	9.95
1881	5.40	5.24	10.64
1882	5.01	4.75	9.76
1883	4.97	3.44	8.41
1884	4.60	1.69	6.29
1885	4.35	1.32	5.67
1886	4.90	2.44	7.34
1887	4.91	3.79	8.70
1888	4.98	4.19	9.17
1889	5.04	4.48	9.52
1890	5.31	4.58	9.89
1891	5.12	3.79	8.91
1892	5.15	4.46	9.61
1893	4.77	4.40	9.17
1894	4.39	3.63	8.02
1895	4.55	4.15	8.70
1896	4.39	4.21	8.60
1897	4.57	4.29	8.86
1898	4.59	4.08	8.67
1899	4.80	4.48	9.28
1900	4.46	4.29	8.75
1901	4.44	3.91	8.35
1902	4.39	4.74	9.13
1903	4.31	4.20	8.54
1904	4.27	4.09	8.36
1905	4.27	4.00	8.27
1906	4.41	4.24	8.65
1907	4.29	4.04	8.33
1908	4.04	3.46	7.50
1909	4.22	4.19	8.41
1910	4.24	4.23	8.47
1911	4.15	4.17	8.32
1912	4.26	4.29	8.55
1913	4.20	3.40	7.60
1914	3.81	3.93	7.74
1915	3.94	4.21	8.15
1916	4.35	5.06	9.41
1917	4.84	5.34	10.18
1918	5.40	5.30	10.70
1919	5.49	5.40	10.89

In this connection it should be stated that bank deposits and bank loans are practically equal.

Hitherto economists have failed to give proper consideration to the effects of custom and habit in determining the ratio of currency payments to check payments. Failure to do so has led to much erroneous reasoning. In addition, the apparently insignificant part played by currency in transacting modern business has misled most economists.

I have shown that in 1910 the total sales of commodities in America was about 100,000 million dollars. Table II shows that in 1910 there were about 15,600 million dollars of bank deposits. In 1910 there were about 3,100 million dollars of currency in circulation, only half of which was in bank reserves. Evidently nearly all the 15,600 million dollars of bank deposits in 1910 represented arrearage in payment of debts incurred by business men in purchasing commodities, paying wages, etc. This arrearage, therefore, was about one-seventh of the total 100,000 million dollars' worth of commodities sold during the year, for all payments for services eventually result in payments for commodities. One-seventh of 365 is 52, which is approximately the average number of days that business men were (in 1910) in arrears in payments as a consequence of loans secured from banks. This 52-day arrearage in payments would be transferred from the ledgers of banks to the ledgers of wholesalers, manufacturers, etc., were there no banks. This arrearage in making payment, appearing as it does in the form of bank deposits, has confused nearly all modern political economists. Noting that bank deposits total about 5 times the total currency, they have been misled into thinking that "credit currency" (that is, checking deposits) is a great factor in determining price levels, when, in truth, nearly all of this "credit currency" is merely an evidence of debt, and has no effect whatever upon price levels, in the long run. Its sole effect is manifested when bank loans are increased above or decreased below the normal ratio to total sales of commodities, that is, when V departs from the normal.

Failure to grasp this fact is at the bottom of most of the errors that government have made in expanding their currency; for it has been argued that since even a great increase in the percentage of currency is only a small increase relative to the total bank deposits, no appreciable rise in commodity prices would occur by increasing the currency greatly. Few economic blunders have exceeded this one in the magnitude of its ill effects. Every great modern war has seen a repetition of this blunder, for paper money has been put into circulation in large quantities.

Paper money, it has been held, is not different in essence from bank checks. But this is not true. Paper money circulates from hand to hand, exactly like silver or gold, whereas bank checks do not. Moreover (and this is more important), most paper money that is "legal money" is usable as bank reserves, whereas checks are not thus usable. In the light of what has been said about the two functions that currency performs when used as bank reserves, a little study should make it clear that since bank checks serve only one of these two functions (whereas paper money serves both functions), it is fallacious to contend that paper money is not different in essence from "credit currency" (or checking deposits).

Only one more important element remains to be considered in discussing bank deposits, namely, whether "non-checking deposits" should not be deducted from total bank deposits. Deposits not subject to check are about half of the total individual bank deposits. Table VI shows the relative constancy of this ratio. But even if the ratio were not constant, there would be nothing gained in precision by eliminating non-checking deposits in calculating the value of V (relative rate of money turnover). Take for example, a deposit of gold money in a savings bank. While the depositor may not check against his deposit of gold, the savings bank may make loans based on that gold money, and these loans will appear at once as checking deposits in other banks. If the savings bank uses the gold to purchase bonds, the gold finds its way to other banks that use it as a basis for loans. The existence of non-checking accounts merely makes it possible to enlarge the credit structure built upon a given foundation of lawful money. As a result, we have about $10 of individual bank deposits to every dollar of lawful money in bank reserves. In this connection it may be noted that bank loans normally are about equal to individual bank deposits.

Having found a correct and simple method of measuring the rate of turnover of bank deposit (V), it remains to show that the same rate holds true also of all currency in circulation.

"Currency in circulation" means all currency not in the national treasury, and that ordinarily amounts to about 90 per cent of all the currency in America. In 1890 about 35 per cent of all the currency in circulation was held by the banks, but by 1911 the percentage had risen to 50. I have already shown why any change in this percentage has no effect upon price levels, because an increase in currency held by banks as reserves merely acts as an insurance fund that permits the building up of a larger amount of bank loans, which loans differ in no essential from other time limit credits. But why is it permissible to assume that the rate of annual turnover of currency outside of banks is approximately the same as the rate of annual turnover of bank deposits?

Practically all currency is constantly flowing into the banks and out again, the bank reserves being only part of the total. A bank, therefore, resembles a reservoir or lake into which water is flowing, only to flow out again. We may conceive all the banks in America to be like all the artificial and natural water reservoirs (lakes, etc.) in America. We may conceive the clouds to be like the individual purses that carry the currency to the banks. We may conceive the rivers to be like the "pay envelopes" that carry the currency away from the banks. The average velocity of a given volume of water can be accurately calculated if we know the number of times that a reservoir is filled in a given period by the water. In like manner the average velocity of currency circulation can be estimated by ascertaining the number of times the bank reserves are turned over in a year. But since bank deposits are normally about ten times the bank reserves, the relative rate of turnover of bank reserves is ordinarily about the same as the rate of turnover of bank deposits. Hence the relative rate of turnover of bank deposits is practically the same as the relative rate of turnover of all currency.

There is another way of viewing this matter that leads to the same conclusion. If currency outside of banks turns over more rapidly than that in bank reserves it is correspondingly more efficient. A greater efficiency thus produced would lead to a diminution in bank reserves and an increase in currency outside of banks, until the efficiency of the currency outside of banks became equal to that of bank reserves. This equalizing of the rates of turnover of currency, whether in bank reserves or outside, is inevitable, just as it is inevitable that water in two tanks connected by a pipe will come to the same level in both tanks if their walls are high enough to permit this result without overflowing.

As will be shown later, we are not concerned with the absolute rate of turnover of currency, but only with its relative rate. It is this relative rate that appears (the V, T and t) in my price formulas.

Speculative Trading and Its Effect on Bank Clearings. Although I have already discussed this matter at some length, it is necessary to call attention to the fact that prior to May 18, 1892, the clearings of the New York stock exchange and the New York bank clearings were lumped together. On

TABLE VI—TOTAL BANK DEPOSITS AND CHECKING DEPOSITS (OR "CREDIT CURRENCY").

Year	Millions of Dollars	
	Total bank deposits.	Checking deposits.
1891	4,361	2,261
1892	4,482	2,325
1893	4,944	2,615
1894	4,834	2,510
1895	4,849	2,578
1896	5,167	2,731
1897	5,122	2.688
1898	5,245	2,747
1899	5,871	3,198
1900	6,964	3,865
1901	8,817	4.205
1902	9,501	4,955
1903	9,953	5,367
1904	10,288	5.853
1905	11,735	6,559
1906	12.546	6.863
1907	13,553	7,109
1908	13,166	6,522
1909	14,687	6,808
1910	15,658	7,713
1911	16,332	8,242

Foot Note—Total bank deposits are taken from Table II. Checking Deposits are taken from Mitchell's "Business Cycles."

May 17, 1892, the New York stock exchange clearing house was established, and thereafter all stock exchange clearings were omitted from the total bank clearings in New York City. As above stated, I have deducted twice the value of the stock and bond sales from the New York bank clearings, for each year from 1893 to 1919. But for years prior to 1892, it was evidently necessary to deduct four times the New York stock and bond sales from the so-called New York bank clearings, because of the doubling effect attributable to the fact that New York stock exchange and New York bank clearings were lumped together.

Since the bond sales have been very uniformly equal to 10 per cent of the stock sales, it is simpler and sufficiently accurate to deduct 2.2 times the stock sales since 1892 and 4.4 times the New York stock sales prior to 1892, and this is what I did in deriving the "curve" of "adjusted" New York bank clearings shown in Fig. 1. For the year 1892 (part of which was on the old basis and part on the new), I deducted 3 times the stock sales. It will be seen that the "curve" of adjusted New York clearings follows the "curve" of clearings outside of New York very closely, except in 1884 and 1885, and in 1875. Both of these are "panic periods." In one case the "adjusted" New York clearings were abnormal; in the other case the outside New York clearings were abnormal.

Clearings outside of New York were not available prior to 1879, at which time there were 22 clearing houses whose records have been compiled (see Table IV). Prior thereto, however, I was able to secure the annual clearings in Boston and Philadelphia back to 1859, and of Chicago back to 1865.

If the New York city clearings are deducted from the total clearings in the last column of Table IV, the remainder is the clearings outside of New York, which I have plotted on Fig. 1 for every year back to 1879.

I noticed that the Boston clearings when multiplied by 3.8 gave a product that agreed very closely with the clearings outside of New York for the years 1879 to 1889. Accordingly I decided to use Boston clearings as a basis for calculating clearings outside of New York from 1859 to 1882, by multiplying them by 3.8. There were, however, five years (1862, 1865, 1867, 1868 and 1881) when Boston clearings were abnormal. This abnormality was due to abnormal stock sales on the Boston stock exchange; so for those five years I used the Philadelphia bank clearings instead of the Boston bank clearings, multiplying Philadelphia clearings by 5.05, which is the factor that expresses the average ratio outside New York clearings to Philadelphia clearings. By this method I was able to approximate the clearings outside of New York for the 20 years (1859 to 1878) in which they were missing.

The next step was to try to check these results (which are shown in Fig. 1) by "adjusting" the New York clearings for each of the years 1859 to 1878. I was unable, however, to secure the New York stock sales for all the years. Table III gives the data as far as they were obtainable. I learned, moreover, that during the period that gold was at a premium (1861 to 1878), gold was sold on the stock exchange, often in large quantities. Obviously such sales of gold would affect bank clearings precisely as stock sales did. During the years 1865, 1866 and 1867 there was a federal tax on both stock and gold sales, from which I was able to deduce the following:

	Millions of dollars
Year ending June 30, 1865:	
Stocks and bonds sold	$4,406
Gold sold	420
Total	$4,826
Year ending June 30, 1866:	
Stocks and bonds sold	$2,860
Gold sold	1,046
Total	$3,906

Taking half of each of these two totals and adding them together should give approximately the total stock, bond and gold sales for the calendar year of 1865. Multiplying this total by four and deducting from New York clearings for the calendar year 1865, should give the "adjusted" New York clearings, and this should check approximately with the clearings outside of New York estimated as above described. As a matter of fact the check is almost perfect, as anyone may see by performing the calculation with the data given in Table IV.

Total bank deposits prior to 1875 are not available, but the ratio of bank deposits to currency in circulation averaged 2.5 to 1 from 1875 to 1885 (see Fig. 2). Accordingly I estimated bank deposits from 1859 to 1871 inclusive by multiplying total currency by 2.5 and I prorated the increase in this ratio up to the year 1879, as shown in Fig. 2.

Taking the critical years of 1860 and 1865, I applied my formula. with results that are astonishingly close to the actual index prices for those years, as may be seen in Fig. 1 and Table I.

The Effect of "Money Turnover" on Price Levels. That the rate of money turnover affects average commodity prices is not evident at first thought. Indeed, to some men, it seems contrary to reason even after the reasons are explained to them. "The swapping of horses cannot add to the value of horses. How, then, can the swapping of dollars for commodities affect their relative value?" This question is often regarded as unanswerable, but it is readily answered.

Mere trading back and forth, whether in horses, in goods, or in stock and bonds, does not affect the general level of prices. It is for this very reason that, in arriving at a value for the rate of money turnover (V) in my formula, I eliminate the effect of New York exchange sales of stocks and bonds.

In order to simplify matters so that the effect of the rate of turnover of money will be clear, let us assume the existence of a community in which all business transactions are in money, and that settlements are made the first of every month.

If each worker in the community averages 30 units of product per month, and if $30 is paid for his product at the end of the month, the price is $1 per unit of product. Now assume that the total money available for paying all workers is doubled, then there will be $60 available to pay each worker monthly, and for his 30 units of product he will receive $2 per unit.

If the community, having been accustomed to a wage payment and other debt settlement once a month, now changes its period of settlement to twice a month, and if the same total amount ($60) of money is paid out twice a month instead of once a month, it will be exchanged for half as many units of product, hence the unit price will be doubled.

Thus, if each worker averages 30 units of product per month, he will produce 15 units in half a month and if he receives the $30 for his two weeks product, he will get $2 per unit. But, it may be asked, why will he receive the full $30 for two weeks' output? Why will he not receive only half of the $30, or $1 per unit of product? The answer is that "money burns a hole in every man's pocket." All the money is kept busy, because it is human habit to spend it. If all employers who had been paying their employes at the rate of $30 once a month for 30 units of product were suddenly to change the payment period to twice a month, they would find themselves in possession of $15 of idle money per employe. The effect of this would be to cause them to try to put that idle money to work. Since that can be done only by hiring more men, there would result a competitive bidding for the services of employes that would soon double their former daily wages, thus doubling the cost of each unit of their daily product, thus doubling its former price.

Economists who have tried to explain this phenomenon have hitherto failed to lay stress upon the fact that, once the average payment period becomes fixed by custom, thereafter that period changes only because of mental excitement or mental depression in relation to business prospects. For example, if wholesale commodities are paid for, on the average, once every month, and if retail commodities are paid for every week, the average of the two kinds of payments may be a payment every 12 days. This would result in an average turnover of all the currency 30 times a year, if there were just enough currency to pay for all the commodities produced every 12 days.

This average 12-day payment period being in existence, and the rate of turnover of money being 30, there will occur oscillations from this average, as the result of psychological causes. For example, suppose a war begins, and the government begins issuing bonds to secure money. It enters the market both for commodities and labor, on a large scale. Immediately it becomes apparent that certain prices will rise—

prices for steel, textiles, etc. At once, business men in those lines begin to anticipate the rise by stocking up. Business men find it easy to borrow money, because bankers also foresee greater profits. The result is to lead business men to pay more promptly the bills rendered for raw material and wholesale purchases, so as to secure the discount for cash payments. This shortens the average payment period from, say, 12 days to 11 days, or makes money turn over about 8 per cent more rapidly. Almost immediately, prices rise 8 per cent. On a rising market, almost anyone in business can make money by stocking up with goods, so a further borrowing from banks occurs, bills are still more promptly paid, and the average payment period drops to 10 days (average of retail and wholesale trade), or a money turnover 17 per cent more rapid than prior to the war. Average prices soon rise this 17 per cent, otherwise there would be idle money.

The converse of this process ultimately occurs after the close of the war. The rate of money turnover decreases and prices begin to recede, unless one or more of the other three factors (M, P, E) given in my price formula offset the effect of the tendency of the rate of money turnover (V) to decrease.

In a primitive community, the existing quantity of money would automatically fix the number of times the money would have to be turned over annually to conduct the business of the community. But, once this rate of money turnover had thus become automatically fixed, the credit period would be established. Thereafter, any change in this credit or payment period would be resisted, for few things are so persistent as human habits and customs. Thus, if workers become habituated to weekly payments, any suggestion that the payment period be lengthened to two weeks is met with strong resistance. The worker, be it remembered, extends credit to the employer when he does not secure daily pay for services rendered.

It follows that, once an average payment period has become established in a nation, the rate of money turnover oscillates about a normal average. This is well seen in Figure 3, where it will be noted that the normal value of T in one of my price formulas is about 4.5, and that T has not departed from this average more than 20 per cent but twice during the past 60 years.

In 1919, the value of V was 10.89 (See Table V). A shrinkage of 20 per cent of this value of V will bring V back to what it averaged during the 10 years preceding the world war. This entire shrinkage (20 per cent) will probably occur within two years after average prices once start to shrink, if we may judge by the rate of shrinkage that occurred immediately following our Civil War.

I have already shown that there is no probability that the total quantity of currency in circulation in this country will decrease materially for many years, but that, on the contrary, the probability is that it will increase somewhat by shipments of gold from Europe in partial liquidation of European debts to America. We now see that a slackening of business activity back to the pre-war ten-year average (or normal) will cause a decrease of only 20 per cent in average wholesale prices of commodities.

The Effect of Population on Prices.—It is not apparent to most men at first sight that a change in population will affect commodity prices. To make it clear that it does have an effect, it is necessary only to consider total population in relation to total currency. The total currency (M) divided by total population (P) is currency per capita. If other things remain unchanged but if currency per capita increases, the average person has more buying power, and if he exercises this buying power, the average price of commodities rises. Conversely, if currency per capital decreases, the buying power of the average person decreases, and prices fall. This may be made clear by an example.

If there are 30 units of monthly product per capita, and $30 of money with which to pay therefor once a month, the average unit price is $1. But now suppose the population to double while the total supply of money remains constant. Then the per capita money available for the monthly betterments becomes reduced to $15. If the 30 units of product per capita remain unchanged, then these 30 units will be exchanged for the $15, and the price per unit will be $0.50, or half what it was before. In other words, if the population doubles, while other factors remain unchanged, average unit prices will be cut in two. In general, then, average prices vary inversely with the total population.

Prior to the world war our population was increasing at the rate of about 1.6 per cent annually. The effect of this would have been to tend to decrease average prices 1.6 per cent annually if the total currency had not changed in quantity.

About one-quarter of this gain in population was attributable to immigration. Immigration has been practically balanced by emigration since 1914, hence our increase in population has not exceeded 1.2 per cent annually during the past five years. Abnormal deaths from the great influenza epidemic has probably reduced the increase to about 1 per cent, instead of the normal 1.2 per cent.

There is little probability that this country will ever again permit so great a rate of an immigration as occurred during the ten years prior to the world war. In any event, it is safe to say that for several years to come our increase in population will be under 1.5 per cent annually. Hence it follows that this factor (P) in my price formula will not tend to lower average prices by more than 1.5 per cent yearly. As an offset to this, however, it is probable that our total currency (M) will increase about 8 per cent in 1920, and thereafter that its increase will fully equal the rate of increase in population. Hence no reduction in the present price level can be expected for several years as a consequence of growth in population.

By way of contrast, consider the effect of the rapid increase in population that followed the close of our Civil War. Table II shows that population increased more than 2 per cent per annum for many years following our Civil War. The population in Table II for the 10 years following the last census year (1909) is that estimated by the U. S. Census Bureau. For the years since 1914, the estimate is probably too high, because the bureau has made no allowance either for the decrease in immigration or for the abnormally high death rate. It is probable that the estimate of population for 1917 is 3 per cent too high. If so, the correct population (P) when used in my price formula will give an index price 3 per cent higher for 1919 than that shown in Table I and in Fig. 1, thus bringing my calculated index price into even closer agreement with the actual index price for 1919.

In this connection, it may be well to point out that the U. S. Bureau of Labor index prices have usually agreed quite closely with those of Dun's (Mercantile Agency) Review, since 1898, when both are reduced to the same base price year, e. g., 1913. To reduce the Dun wholesale index prices to the year 1913 as a base of 100, multiply them by 0.83. Then they can be compared with those of the U. S. Bureau of Labor. Table I gives the comparative figures.

The Effect of Productive Efficiency on Prices.—It is easy to see that as the average output of workers increases average prices will decrease, if other things remain unchanged, and conversely. For example, if each worker averages 30 units of product monthly, and if $30 is paid to each worker monthly for his product, the price per unit of product is $1. If a constant amount of money per worker, say $30, remains in circulation and is turned over the same number of times annually, then if the output of each worker is doubled, becoming 60 units per month, the average price per unit will be $30 ÷ 60, or 50 ct., or half what it was before.

In general, if the other factors that affect prices remain the same, any change in the output (or productive efficiency) of a nation will cause an equal change in average commodity prices, but inversely or in the opposite direction.

The truth of this important generalization has been more or less clearly recognized for a long time by many thinkers; but, so far as I know, there has hitherto existed no thoroughly conclusive evidence that this generalization is correct. Accordingly I have taken great pains to establish the generalization, first by induction, second by deduction.

I will show the actual wages paid to American workers for the past 60 years, and the corresponding buying power of those wages, and I will show that wages doubled in the 50 years from 1859 to 1909, while the index prices for those two years were substantially the same. From this it will be evident that the buying power of average wages in America doubled in that 50-year period. I will show that the productive per capita output of the American people doubled in the 40 years from 1869 to 1909, and since then has not increased. The per capita productive output for 1859 cannot be ascertained with great accuracy, but it was approximately the same as in 1869. Hence it must follow that average wage rates have kept pace with average productive efficiency.

I will prove deductively that average commodity prices very inversely with average productive efficiency. To do this I will derive relative values for per capita productive efficiency (E), based on the total actual output of commodities by 10-year periods from 1869 to 1919. Having thus derived the values for E, I substitute them in my price formula and deduce the wholesale index price for every year for the past 50 years. Since the index prices thus deduced agree very closely with the actual index prices, it follows that deductive proof has been secured to establish the generalization that average prices vary inversely with average productive efficiency.

The Buying Power of Wages.—The heavy curving line in Fig. 1 is the curve of relative daily wages, from 1859 to 1907. This is based in part on data published in one of the most noteworthy public documents ever printed, namely, the "Aldrich Report," or Senate Report No. 1394, a three-volume report issued March 3, 1893. That report contains a great mass of statistics on wholesale prices and wages for every year from 1840 down to 1891. On the subject of daily wage rates Table IX is typical, being the summary for the year 1891. Table IX is a simple average, but weighted averages were calculated for every year. The weighted average for 1891 was 168.6, as compared with the unweighted average of 160.7. This means that in 1891 the weighted average daily wage was 68.6 per cent higher than it was in 1860, measured in currency.

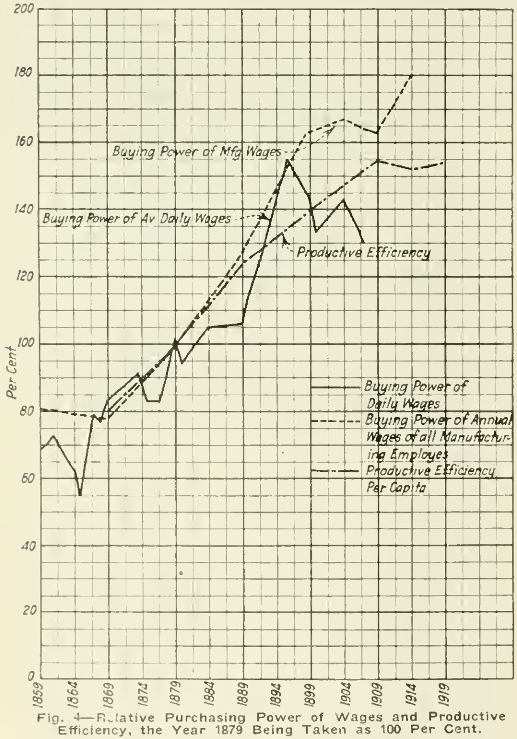


Fig. 4—Relative Purchasing Power of Wages and Productive Efficiency, the Year 1879 Being Taken as 100 Per Cent.

For 1890 to 1907, inclusive, the U. S. Bureau of Labor compiled similar relative average daily wages, but since 1907 the bureau has unfortunately confined its wage studies to a limited number of industries. Hence the relative daily wage curve in Fig. 1 ends with the year 1907. As before stated, the year 1860 is taken as the base year, with a daily wage value of 100 per cent. Note that at 1907 the daily wage has reached 200, having doubled in 50 years. Note also that the index price was 90 in 1860 and that it was 91 in 1906, 96 in 1907, and 9[illegible] in 1908. In short, the purchasing power of a dollar was substantially the same in 1907 as in 1860, during which period average daily wages had doubled.

Data Showing Productive Efficiency.—Observing the fact just stated, I inferred that the average productivity of American workers must have doubled in that same period of time. Accordingly I undertook to ascertain what had been the fact as to the increase in average productivity.

Prof. King, in his "Wealth and Income of the People of the U. S.," has given some estimates of the average annual incomes of several different classes of producers, expressed in buying power as well as in dollars. But he does not give the increase in average income per capita or per worker for all those classes of producers combined, and it was this general average that I was seeking. Moreover, I found that through not going to the original sources, Prof. King had made several errors both in the actual data and in his interpretation of them. For example, he did not realize that the statistics as given in the Statistical Abstract relating to the value of agricultural products are not at all comparable for the different census years, a fact that is pointed out in the volumes of the U. S. Census. In several instances Prof. King used incorrect index prices, e. g., simple averages where weighted averages should have been used.

In order to reduce to a minimum any errors that might arise from the use of incorrect price indexes, I decided to secure, as far as practicable, the number of units of product in each of the four grand classes of producers of commodities sold at wholesale, namely (1) Agriculture, (2) Mining, (3) Manufacturing, and (4) Transportation by Rail. I found it possible to secure all the needed data for every year back to 1869, except for manufactured products and for transportation. Steam railway transportation, however, could be carried back to the year 1882, for both the numbers of tons and ton-miles of freight were available.

Table X gives a general idea of the distribution of those engaged in gainful occupations, but too rigorous a comparison between successive census years should not be made, especially between 1899 and 1909, because of differences in the classification rules followed by the census takers in different years.

Efficiency of Transportation.—About 40 to 50 per cent of those classed as engaged in transportation are steam railway employes, but none of the railway shopmen are included, as they are classed under mechanical. About one-third of the transportation workers are draymen and teamsters. There is no way of ascertaining the productive efficiency of any of the transportation workers, except those engaged on railways. From the statistics that I gathered as to ton-miles and

TABLE VIII—RECENT PRODUCTIVITY.

	Millions of units.					
	1913.	1914.	1915.	1916.	1917.	1918.
Cotton, bales used	5.79	5.88	6.01	7.28	7.66	7.69
Wool, lbs. used....	491	538	586	819	652	678
Pig iron, tons	30.97	23.33	29.92	39.43	38.65	39.05
Steel, tons	31.30	23.51	32.15	42.77	45.06	44.46
Copper, tons	.55	.51	.62	.86	.84	.89
Lead, tons	.41	.51	.51	.55	.54	.51
Coal, tons	509	459	475	527	641	581
Lumber, ft. (B. M.)	38,387	37,346	37,012	39,807	35,831	a31,890
Wheat, bu	763	891	1,026	639	651	917
Corn, bu.	2,447	2,673	2,995	2,567	3,159	2,583
Hay, tons	64.12	70.07	85.92	91.19	85.36	75.46
Cattle, on farms ..	56.53	56.59	58.33	61.92	64.58	67.42
Swine, on farms ..	61.18	58.93	64.62	67.77	67.50	70.98
Sheep, on farms..	51.48	49.72	49.96	48.63	47.62	48.60
Freight, ton miles.	301,399	288,320	276,830	343,100	a365,772	a398,263

Foot Note—These data are taken from the Statistical Abstract of the U. S. for 1918, except the numbers marked a, which are from the World Almanac for 1920.

TABLE IX—RELATIVE WAGES IN 1891 AS COMPARED WITH 1860 TAKEN AS 100. ALDRICH REPORT.

(Simple Average.)

	Industry.	Number of quotations.	Relative wage.
1.	Agricultural implements	5	137.9
2.	Ale and beer	5	224.7
3.	Books and newspapers	21	148.6
4.	Building trades	39	172.5
5.	Carriages and wagons	4	202.4
6.	City public works	23	164.6
7.	Cotton goods	131	165.1
8.	Dry goods stores	3	183.6
9.	Ginghams	30	152.7
10.	Grocery stores	2	191.7
11.	Illuminating gas	22	167.7
12.	Leather	16	137.6
13.	Lumber	5	177.9
14.	Metals and metallic goods	130	148.6
15.	Paper	7	182.3
16.	Railroads	11	146.4
17.	Sidewalks	4	187.5
18.	Spice	5	164.2
19.	Stone	19	165.2
20.	White lead	3	140.6
21.	Woolen goods	58	167.8
	Total	543	160.7

TABLE X—GAINFUL OCCUPATION STATISTICS.
(Thousands.)

	1869.	1879.	1889.	1899.	1909.
Agriculture	5,922	7,714	8,148	10,382	12,568
Professional	372	603	944	1,259	1,825
Domestic and personal	2,302	3,418	4,221	5,581	5,361
Trade and transportation[2]	1,240	1,872	3,326	4,766	7,606
Manufacturing and mechanical[1]	2,670	3,785	5,687	7,085	10,807
Total gainful occupation	12,507	17,392	22,318	29,073	38,167
Total population	37,756	48,866	61,289	74,318	90,557
Fishermen	....	41	60	69	68
Building trades	....	681	1,135	1,212	1,661
Mines and quarries	163	296	531	740	1,177
Transportation[2]	....	587	1,131	1,515	2,465

Foot Notes:

[1] Manufacturing and mechanical includes fishing, building trades, mines and quarries, railway shopmen.

[2] Transportation includes railways (exclusive of shopmen), telegraph and telephone linemen and operators.

tons of freight per railway employe (including railway shopmen) I derived the following:

Tons of freight per railway employe in 1889 were 843; in 1909, the tonnage was 1,036; in 1914, 1,155; or an increase of 37 per cent in 25 years, or about 1.5 per cent yearly. Calling a passenger-mile equivalent to 2.5 freight ton-miles, the equated ton-mileage per railway employe in 1889 was 131,576; in 1909 it was 194,019, and in 1914 it was 220,017, or an increase of 70 per cent in 25 years, or 2.8 per cent yearly.

Viewed from the standpoint of a railway manager, an increase in ton-mile output per employe is important, but viewed from the standpoint of a political economist it is of far less importance than an increase in the tons of freight per employe. This is because an increase in the average length of haul is of no economic advantage to the nation as a whole, and is really an economic loss unless it is offset by some other productive gain, such as the opening up of more fertile lands or richer mineral deposits.

Since less than 3 per cent of all men engaged in gainful occupation are classed as steam railway employes (under Transportation) in the U. S. Census, no appreciable error can result by omitting them entirely from consideration in seeking the general average productive efficiency of all workers. Moreover, it should be noted that for every railway employe there is an investment of more than $10,000 in the railway plant, or about four times as much per worker as is found either in manufacturing or in agriculture. All this railway plant has been built by workers classed under Manufacturing and Mechanical, and most of its renewals are made by them also. Hence, viewing the problem broadly, the productive efficiency of railway employes is mainly due to men not classed as railway employes. To these reasons another one should be added for not averaging railway employe productive efficiency with that of other men to whom most of it is attributable. If the efficiency of transportation workers is to be considered, all of them should be considered and not merely railway employes; but this is impracticable, because there are no published units of output of any but railway employes, nor are there any weighted price indexes by which transportation costs of all kinds can be reduced to a comparable basis for different years. Finally, it should not be forgotten that a vast amount of transportation is conducted by farmers and others not classed under Transportation.

Efficiency of Building Trades.—The building trades employes must be excluded from consideration because no data as to the value of their total output are available since 1899. For 1899 and prior thereto the building trades output was included by the census with manufacturing output, but I have eliminated it from those years in order to derive a manufacturing output that will be comparable from 1869 to 1914. (Prof. King failed to take into account the above mentioned change in 1899.) The building trades constitute about 4 per cent of the total engaged in gainful occupations. The labor cost of buildings is only 40 to 50 per cent of the total cost, so that the omission of the building trades from the total of productive workers is even less important than the 4 per cent would indicate.

Finally, it should be remembered that we are seeking a productive efficiency factor to use in a wholesale commodity price formula, and the building trades employes have very little influence on this factor.

For similar reasons, workers classed under Domestic and Personal Service and Trade can be omitted from consideration. The same holds true of Professional service, for although a very large part of the increase of productive efficiency it attributable to professional men (educators, engineers, etc.), it finds its measure in the better work done by the workers, which is exactly what we are seeking to determine.

Efficiency in Agriculture, Manufacturing and Mining.—We have left, then, those engaged in Agriculture, Manufacturing and Mining. These occupations comprise about two-thirds of all people engaged in gainful occupations, and they comprise fully 85 per cent of all workers who produce wholesale commodities. Hence if we ascertain the average productive efficiency of these three classes, we shall have a very accurate measure of the productivity of all producers.

The census data for 1859 and earlier years are not comparable with those of later years, because slaves were not counted as being engaged in gainful occupations, although they were counted as part of the population. In 1859 negroes were about 15 per cent of the population.

The Efficiency of Miners.—Practically all the miners in America are engaged in producing seven minerals and metals: Coal, iron ore, copper, gold, silver, lead and zinc. Hence if we ascertain the annual number of units of each of these minerals and metals produced at intervals of 5 or 10 years, and multiply by standard unit prices we shall be able to compare one year's output with another. Then if we divide the total output in dollars for each year by the number of miners engaged in that year, we shall have the gross output in dollars per miner per year. But from this should be deducted the value of new equipment and of materials and supplies used in mining, which, according to the U. S. census, has averaged about 30 per cent of the gross value of the mineral output.

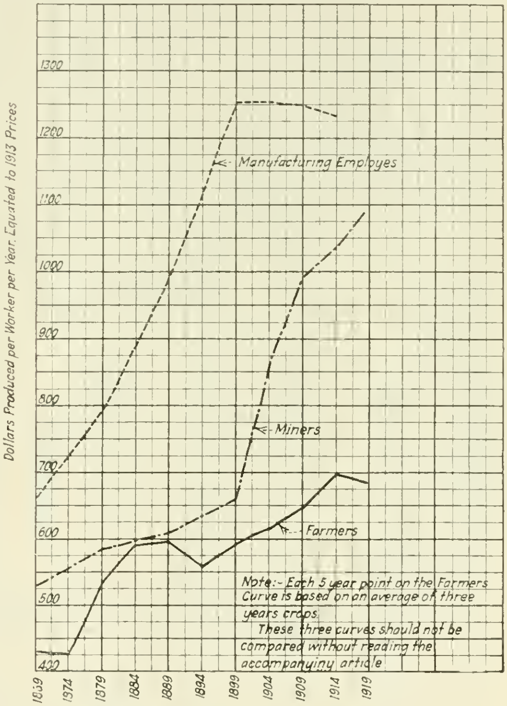


Fig. 5—"Equated Productivity" Per Worker (Dollars Per Annum).

Table XIII gives two typical years, 1869 and 1918, for which I have calculated the gross value of the 7 minerals and metals, using prices that approximate to those of 1913. The gross mineral values for 1869, 1879, 1889, 1899, 1904, 1909, 1914 and 1918 being thus determined (always using the same standard unit prices), 70 per cent thereof was taken (to get the value after deducting raw materials, supplies and additions to plant), and the net values thus derived for each of these years were divided by the number of miners employed during that year. This gave net value produced per miner for each of the years, which is graphically shown in Fig. 5. A similar result is shown graphically in Fig. 6, but there expressed as percentages (instead of in dollars), taking the year 1879 as 100 per cent. Table XIV shows the same results, and the footnotes describe the methods of calculations. The numbers in column A of Table XIV, when multiplied by 70 per cent, give the dollars per miner per year shown in Fig. 5; the numbers in column E (or efficiency per miner) are shown in Fig. 6. It will be seen that the productive efficiency of the miners has more than doubled in 50 years, rising from 91.7 in 1869 to 187.8 in 1918. It is particularly noteworthy that their efficiency has increased more rapidly in the last 30 years of this 50-year period than in the first 20 years. In 1917 the coal miners (and they comprise 80 per cent of all the miners) broke all records for output per miner, mainly because they worked about 20 per cent more days per annum than in normal years. The output for 1918 also was abnormal. Had I used the abnormally high output that actually occurred for 1918, the result would have been a gross equated output of $1,902 per miner instead of the $1,550 given in column A of Table XIV. But since we are seeking the average efficiency of all workers in America, this abnormal output of the coal miners for 1918 would give us a false result, so both in Table XIV and in Figs. 5 and 6, I have scaled down the mining output to that of a normal year.

With the same number of coal miners about 20 per cent more coal was mined in 1917 than in 1914. This achievement shows conclusively what may be accomplished in the way of improving the efficiency of the coal mining industry.

The data of annual output of the mines are to be found in the Statistical Abstract of the United States.

TABLE XI—CROP DATA FOR TWO PERIODS, 1869 AND 1918.

Crop.	Millions of units.	Unit price.	Total millions, dollars.
Period of 1869.			
Corn, bu.	958	$0.55	527
Wheat, bu.	240	1.00	240
Oats, bu.	263	0 40	105
Barley, bu.	26	0.60	16
Hay, ton	25.70	12.00	308
Potatoes, bu.	118	0.60	71
Cotton, bale	2.65	55.00	146
Tobacco, lb.	393	0.10	39
Sugar, lb.	80	0.025	2
Total			1,454
Period of 1918.			
Corn, bu.	2,871	$0.55	1,579
Wheat, bu.	784	1.00	784
Oats, bu.	1,563	0.43	625
Barley, bu.	278	0.60	167
Hay, ton	80.41	12.00	965
Potatoes, bu.	422	0.60	253
Cotton, bale	11.50	55.00	633
Tobacco, lb.	1,295	0.10	130
Sugar, lb.	2.143	0.025	54
Total			5,190

Foot Note:

The crop quantities for the "Period of 1869" are the average for the three years of 1868, 1869 and 1870. The crop quantities for the "Period of 1918" are the average for the two years of 1917 and 1918.

TABLE XII—FARMING EFFICIENCY.

	A	B	C	D	E
"Period."	Average per year per worker for 9 crops.	Average per year per worker for all products.	Number of workers in thousands.	Equated value of all crops in millions of dollars.	Efficiency per worker.
1869	$246	$430	5,922	$2,545	80.4
1879	306	536	7,714	4,130	100.0
1889	340	595	8,566	5,103	111.1
1899	353	613	10,382	6,414	115.4
1904	359	629	11,522	7,238	117.3
1909	365	638	12,159	7,767	119.3
1914	375	647	12,660	8,309	122.5
1918	383	[illegible]	13,060	8,754	125.2

Foot Notes:

Column A gives the equated average annual gross output of agricultural workers, for the 9 leading crops per year per worker (see Table XI for two typical "Periods").

Column B is the value in column A multiplied by 1.75, giving the per worker equated value of all farm products.

Column D is one-thousandth of the product of the numbers in columns B and C.

Column E is derived by dividing the numbers in column A by 536, the 536 being the equated value of all farm products per farmer for the "period" of 1879; this year, 1879, being taken as a standard for comparing the output during each of the "periods."

The word "period" is used to designate the average crop for three years, as explained in the article and in Table XI

TABLE XIII—MINING DATA FOR TWO YEARS, 1869 AND 1918.

Mineral.	Millions of units.	Unit price.	Total millions of dollars.
Year 1869.			
Coal, long tons	29.38	$ 1.50	44,07
Copper, long tons	0.01	300.00	3.00
Iron ore, long tons	3.03	2.00	6.06
Gold, oz.	2.39	20.70	49.47
Silver, oz.	9.28	1.00	9.28
Lead, short tons	0.02	100.00	2.00
Zinc, short tons	0.01	120.00	1.20
Total			115.08
Year 1918.			
Coal, long tons	581.61	$ 1.50	872.42
Copper, long tons	0.89	300.00	267.00
Iron ore, long tons	75.57	2.00	151.14
Gold, oz.	3.31	20.70	68.52
Silver, oz.	67.88	1.00	67.88
Lead, short tons	0.54	100.00	54.00
Zinc, short tons	0.58	120.00	69.60
Total			1,550.56

TABLE XIV—MINING EFFICIENCY.

	A	B	C	D	E
Year.	Equated output per miner.	Number of miners.	Total equated value, millions.	70% total equated value, millions.	Efficiency.
1869	$ 757	152,107	$ 115	$ 81	91.7
1879	825	234,228	193	135	100.0
1889	915	387,248	354	248	110.9
1899	1,112	563,406	627	439	134.8
1904	1.232	670,562	826	479	149.3
1909	1,393	777,719	1,084	759	168.8
1914	1,479	818,647	1,211	842	179.2
1918	1,550	815,230	1,264	885	187.8

Foot Notes:

Column A gives the equated average annual gross output of all miners engaged in producing the 7 leading minerals. (See Table XIII.)

Column B is the number of miners thus engaged.

Column C is one-millionth of the product of the numbers in columns A and B.

Column D is 70 per cent of column C, and this is the equated value produced by the miners after deducting 30 per cent for raw materials and supplies.

Column E is derived by dividing the numbers in column A by 825, the 825 being the equated value of minerals per miner for the year 1879; this year, 1879, being taken as a standard for comparing the output during each of the years.

The standard unit prices of coal and iron that I have assumed in Table XIII, are the prices at the mines; but the rest of the prices are those of the metals in the primary wholesale markets. Since these metal prices include the cost of milling, smelting and freight, the resulting total values (Table XIII) for each year are in excess of the base cost of mining. While this makes it impossible to contrast the dollars produced per miner with the dollars produced per farmer for a given year (Fig. 5), it does not prevent a comparison of the changes in their respective efficiency (Fig. 6), nor does it vitiate the final conclusions as to the per capita productive efficiency of all producers of wholesale commodities, as will be more clearly evident when we come to the discussion of that factor (E). The increased investment in plant per miner has already been taken into consideration, as above described.

Agricultural Efficiency.—In order to measure the productive efficiency of agricultural workers from 1869 to 1918 inclusive, I decided that the most exact method would be to secure the number of units of product of every important crop by years. Upon study of these crop data it became evident that 9 crops comprised 85 per cent of all crop values. Since the other (or minor) crops bear an almost constant ratio in value to the total value of these 9 crops, it is apparent that we need consider only the 9 crops in estimating crop productive efficiency for different years.

Since crops usually vary somewhat from year to year I decided to take the average of three crop years, at five year intervals; thus for the year 1869, the average of the crop yields for 1868, 1869 and 1870 was taken. Then I assumed an average unit price for each of the crops, and multiplied each average crop for the 1869 "period" by the average price assumed. Table XI gives the calculated value of the 9 big crops for 1869 and 1918. The same unit prices used in Table XI were used for 1874, 1879, 1884, etc. at 5-year intervals, taking the average crop yeld for three years in each case.

The annual value of the animals and animal products (beef, milk, eggs, wool, cattle sold, etc.) in any year has averaged about 55 per cent of the value of all the crops. Hence if we multiply the value of the 9 big crops by 1.18 to get the value of all crops, and if we multiply this product by 1.55 we get the value of all agricultural products. The product of 1.18 and 155 is 1.83.

The standard for unit prices assumed in calculating the crop values (see Table XI) were approximately those of 1909 to which about 7 per cent must be added to be equivalent to the price level of 1913, which is the year that I use throughout as the standard of prices. So if we add 7 per cent to 1.83 we get 1.96, which is the factor by which to multiply the value of the 9 crops calculated on the prices given in Table XI, to get the value of all crops and animal products. But it happens that a very considerable part of the farm products are consumed on the farms. The census of 1899 shows that 20 per cent of the total value of all farm products was fed to live stock. On the other hand, the census of 1909 shows that the quantities of animal products and the number of cows reported by farmers were not given in full, a check count showing the omissions as to dairy cows being 2.2 per cent of the total cows. From a study of such data, I have concluded that a deduction of about 12 per cent from the total of agricultural products will give a very close approximentation to the value of farm products after deducting the food consumed by live stock and after adding the value of items that were underestimated in the reports made by farmers. Animal increments in farm equipment are so small a percentage of farm output they need not be considered. Taking this 12 per cent from the factor of 1.96 (above deduced, reduces the factor to 1.745—call it 1.75. Hence if we multiply the total values of the 9 big crops (as given in Table XI for 1869 and 1918, and as similarly calculated for intervals of 5 years between those years) we get the equated total value of farm products after deducting the value of food fed to livestock. The resulting totals for each year if divided by the numbers of agricultural workers give the "equated" annual productivity per agricultural worker.

The word "equated" here means reduced to the same standard prices for the standard year, the standard year in this case being 1913.

Fig. 5 shows the output in dollars per year per "farmer," for each of the 5-year points (each "point" being an average for three years' crops, as above explained), from 1869 to 1918 inclusive. Even though I had largely eliminated the effect of fluctuations in crop yield (by taking 3-year averages), it is evident that the effects of very bad crop failures were not entirely "ironed out." Since we are seeking average annual productive efficiency per capita, it is necessary to "iron out" all irregularities. Accordingly, it is necessary to omit the results for the year 1874 and 1894, for exceptionally large crop failures occurred at those "points." To do this "ironing out," draw a straight line on Fig. 5 from the farmer output in 1869 to that in 1879, thence to that in 1889, thence to that in 1918. This line (which is not shown in Fig. 5, but can be drawn by the reader) may be called the "adjusted curve of output per farmer." It serves merely to "iron out" irregularities of farm productivity due to irregularities in the weather, and thus gives a true measure of the increase in the average productivity per farmer.

Column B of Table XII gives the output per farmer for each of "periods," and corresponds to the "adjusted curve of output per farmer." Column C gives the number of agricultural workers, those for the years 1914 and 1918 being estimated. The meaning of each column is given in the footnotes of the table. Column E gives the productive efficiency per farmer, which is also shown graphically in Fig. 6, from which we see that agricultural efficiency rose from 80 in 1869 to 100 in 1879, then to 111 in 1889, then to 125 in 1918. This in an excellent record for the 20 years following 1869, but a miserable record for the 30 years following 1889. Although this record is bad it would have been worse had I taken the number of people engaged in agriculture as reported in the census of 1909, namely 12,659,000. The census report states that this number is probably about 500,000 high, due to a misunderstanding by the census enumerators, too many women having been classed as engaged in "gainful occupation" on the farms. Accordingly I deducted 500,000, which has resulted in raising the agricultural output about 4 per cent per worker over what it would have been had no correction of the census figures been made. I have estimated a 900,000 increase in agricultural workers between 1909 and 1918, or 100,000 a year, which is only 0.8 per cent yearly, or at half the rate that the total population usually increases. Had I estimated a higher rate of increase in farmers, there would have resulted a lower output per farmer in 1914 and 1918 than that shown in Table II.

The Efficiency of Manufacturing Workers.—I endeavored to ascertain the number of units of annual output of the major classes of manufacturing and mechanical trades, but was only partly successful. The textile trade output can be approximately measured in pounds of cotton, wool and silk used annually. Iron and steel production can be measured in tons of iron and steel. In both the textile and the ferrous (iron) trades the units of product are available for every year back paper are available only for recent years. The annual quan- to 1869, but unfortunately the number of units of leather and tity of lumber produced is available back to 1880. I made studies of the output in the textile trades, the iron and steel trades, and the lumber trades, also partial studies of the paper and printing trades (using the number of tons of wood pulp and paper as units); but I will not give the results of these studies now, because I did not use the data in estimating the average output of all manufacturing workers.

Manufacturing covers such a vast variety of trades that it becomes necessary to use a method differing from the one that I used for deducing the productive efficiency of miners and farmers. Table XV (with its footnotes) shows the method used to deduce the productive efficiency of manufacturing workers from 1869 to 1914.

The method, briefly stated, consists in ascertaining the gross value of the annual product, deducting therefrom the value of the raw materials and supplies, and dividing the net value thus obtained by the index price for the given year. The quotient (column E, Table XV) is the "equated" net value produced by the work of all those engaged in manufacture. If great exactitude is required, this result should be reduced by about 3 per cent, to allow for the annual increment in "equated" investment in manufacturing plant, but this refinement is unnecessary.

TABLE XV—MANUFACTURING PRODUCTIVITY AND EFFICIENCY.

Year.	A Total value of products millions.	B Total value of raw mtls., millions.	C Value added by mfg., millions.	D Weighted index price.	E Equated value added by mfg.
1869 ..	$ 4,232	$ 2,488	$1,744	1.22	$1,430
1879 ..	5,370	3,397	1,973	0.87	2,268
1889 ..	9,372	5,162	4,210	0.86	4,895
1899 ..	13,000	7,344	5,656	0.76	7,442
1899 ..	11,407	6,576	4,831	0.76	6,357
1904 ..	14,794	8,500	6,294	0.84	7,493
1909 ..	20,672	12,143	8,529	0.95	8,978
1914 ..	24,246	14,368	9,878	1.00	9,878

Year.	F Employes, thousands.	G Value per. employe.	H Adjusted value per employe.	I Efficiency.
1869	2,054	$ 696	$ 664	83.9
1879	2,733	830	791	100.0
1889	4,713	1,039	991	125.3
1899	5,670	1,313		
1899	5,077	1,252	1,252	158.3
1904	5,987	1,252	1,252	158.3
1909	7,405	1,212	1,212	153.2
1914	8,000	1,235	1,235	156.0

Foot Notes:

Column A gives the total value of manufactured products in millions of dollars.

Column B gives the total value of raw materials and supplies.

Column C gives the difference between the values in columns A and B, or the value added by manufacture.

Column D gives the weighted actual index prices of all commodities, treated as a percentage.

Column E gives the "equated" value added by manufacture, which is derived by dividing the numbers in column C by those in column D.

Column F gives the thousands of employes.

Column G gives the annual value created per employe, but for the years 1869, 1879 and 1889 this includes the building trades employes, whereas the years 1904, 1909 and 1914 exclude the building trades. Hence two sets of figures are given in the table for the year 1899; the upper set of figures includes the building trades, the lower set excludes them.

Column H gives the equated value created per employe, after "adjusting" for the years 1869, 1879 and 1889 so as to exclude the building trades. This adjustment is made by taking 95.4 per cent of the numbers in column G for the years 1869, 1879 and 1899.

Column I gives the efficiency of manufacturing employes, obtained by dividing the numbers in column H by 791, which is the adjusted value created by the average manufacturing employe in 1879, this year being taken as a standard for comparative purposes.

In selecting the index prices to use in applying this method the choice lies between the weighted wholesale index prices of all commodities (given in Fig. 1 and in Table I), or the weighted wholesale prices of manufactured products. I chose the former, because no satisfactory weighted index prices of manufactured products are available for early years. Moreover, if index prices of manufactured products are to be used, it becomes logically necessary to divide the annual values or the raw materials by weighted index prices for raw materials, and no satisfactory weighted index prices for raw materials are available. Finally, it should be remembered that the finished product of one "factory" often becomes the "raw material" of another factory. Thus, pig iron (the finished product of a blast furnace) may become the raw material of a steel mill; the steel may itself pass through several different factories, the finished products of which are successively raw material for those that follow in the series. Evidently, then, it can not be far from correct, for the present purpose, to use the weighted index prices of all commodities.

Dividing the value of a year's output by the index price for the given year gives an "equated" value that is comparable with that for any other year. By such a method we are able to reduce all values to a common basis, arriving at a result similar to that obtained by the method above described for "equating" the output of miners and farmers.

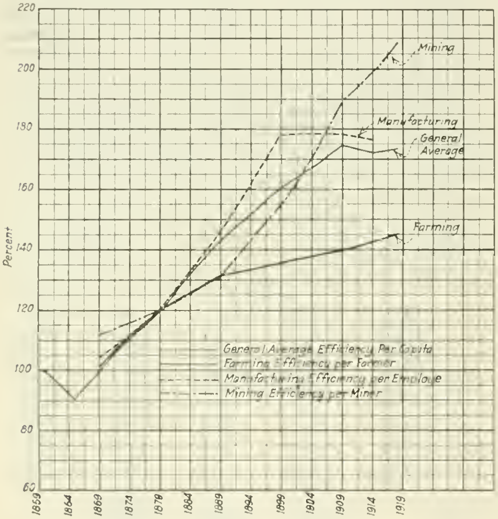


Fig. 6—Productive Efficiency.

Fig. 5 shows graphically the data given in column H of Table XV; Fig. 6 shows the data in column I.

It will be seen that manufacturing workers' productive efficiency or output was 84 in 1869, and rose to 158 in 1899—almost doubling in 30 years. Following 1899 there was no improvement whatever for 15 years (up to 1914), and there is little doubt that some falling off in manufacturing workers' efficiency, per worker, has occurred since 1914. However, the per capita productive efficiency of the nation has not decreased since 1914, because farming and mining efficiency have risen sufficiently to offset any loss in manufacturng efficiency. The proof of this conclusion will now be given:

Productive Efficiency Per Capita.—Per capita productive efficiency has, so far as I know, never been ascertained before, yet its economic significance is of extreme importance, entirely aside from its use in my index price formula. The "real" income of an entire nation consists of the commodities secured and the services rendered; but "services rendered" are, for the most part, rendered in order to secure commodities. Hence we come, in the final analysis, to an expenditure of practically all money income for commodities.

We have already considered the productivity of each of the three great classes of workers who produce raw materials and finished factory commodities. It remains now to secure the combined or composite efficiency of these workers. Before doing so it may be well to point out the economic part by the other classes of workers, namely those engaged in "professional service," "domestic and personal service," "trade and transportation." These three great classes comprise about one-third of all who are engaged in gainful occupations. As will be seen from Table X, this ratio of one-third has been fairly constant for the 40 years, from 1869 to 1909. It is apparent, therefore, that to the cost of producing commodities, there must be added about 50 per cent for transporting and distributing them and for the professional service (educatinal, engineering, etc.) and other services (government, etc.). This explains why retail prices average, on the whole, approximately 50 per cent in excess of wholesale prices, year after year. But the present significance of this constancy of the ratio of the number of "producers" to "distributors, etc.," namely, 2 to 1, is this: If we ascertain the efficiency of the "producers" of commodities sold at wholesale prices, that same efficiency will apply to the "distributors, etc."

Table X shows that the ratio of "workers" (all those engaged in gainful occupations) to total population has increased since 1869. Probably the rate of increase since 1914 has been greater than theretofore, because so many women who were called into gainful service during the war have continued in that service. This should be borne in mind when considering the productive efficiency of the nation as a whole, for it accounts largely for the fact that our per capital efficiency has not decreased during the past five years in spite of a decrease in individual efficiency in many industries and trades. Men unaccustomed to solving problems in political economy are prone to overlook such facts as this, because they are accustomed to reason as to individual efficiency and not as to the mass efficiency of an entire nation.

Table XVI gives my calculation of the per capita productivity and efficiency of the American people, from 1869 to 1918 inclusive.

It will be observed that I have estimated the "equated" value of manufactured products for 1918 at 10 per cent in excess of that for 1914. In arriving at this estimate, I studied all the data of annual production of different commodities, and made a "weighted average" estimate of the resulting percentage increase. Table VIII contains only a small fraction of the data that I used in making this estimate, but it should serve to silence anyone who argues that high prices are attributable to the reduced output of American workers.

Parenthetically let me say that the average business man or banker who "talks for publication" does most of his reasoning about the "high cost of living" in a manner that is reprehensible. Instead of seeking data to show the causes of

TABLE XVI—PER CAPITA EFFICIENCY IN THE PRODUCTION OF WHOLESALE COMMODITIES.

(Column G gives values for E in the author's price formula.)

	A	B	C	D	E	F	G
Year.	Equated agricultural products, millions.	Equated mfg. products, millions.	Equated mining products, millions.	Total of A, B and C.	Total population, thousands.	Per capita products of A, B and C.	Per capita efficiency.
1869	$2,545	$1,222	$ 81	$3,849	37,756	$102	80.3
1879	4,130	1,937	135	6,202	48,866	127	100.0
1889	5,103	4,181	248	9,532	61,289	156	122.8
1899	6,414	6,357	439	13,210	74,318	178	140.2
1904	7,238	7,493	479	15,310	82,467	186	146.5
1909	7,767	9,241	759	17,767	90,557	196	154.3
1914	8,309	9,878	848	19,035	98,646	193	152.0
1918	8,754	10,866	885	20,505	105,118	195	153.5

Foot Notes:

Column A is taken from column D of Table XII.

Column B is derived from column E of Table XV, by taking 85.12 per cent of the numbers given there for the years 1869, 1879 and 1889, in order to eliminate the value created by the building trades. The $10,866,000,000 for 1918 is estimated in the assumption of a 10 per cent increase over 1914.

Column C is taken from column C of Table XIV.

Column D gives the total of columns A, B and C

Column F gives the quotient found by dividing the numbers in column D by one-thousandth part of the numbers in column E.

Column G gives the quotients found by dividing the numbers in column F by 127, so as to express the per capita efficiency in terms of that in the year 1879 taken as 100 per cent.

high prices, such men usually reason deductively from premises that are either assumed outright or are based on insufficient facts. Let such a man observe that his own factory "help" are not as efficient as before the war, and he will at once infer that the same holds true of all other workers in the nation without stopping to consider how infinitesimal are his personal data compared to the grand total. There are more than 40,000,000 people engaged in gainful occupations in America. Let this be remembered when any premise as to general efficiency is based upon "personal knowledge" about a relatively insignificant fraction of these 40,000,000. Also let it be remembered that individual productive efficiency may decrease, but that per capita efficiency may actually increase because a larger percentage of the population has entered the ranks of the workers.

Column G of Table XVI shows the per capita productive efficiency of the American people (the E in my index price formula) and Fig. 6 shows the same data graphically, from 1869 to 1918. Observe that per capita efficiency rose from 80 per cent in 1869, to 100 per cent in 1879 (the year taken as a standard for comparison), then to 146 in 1904, then to 152 in 1914, and finally to 153.5 in 1918. It will be seen than since 1909 there has been very little change in per capita efficiency. It will be seen that, contrary to general opinion, the productive output of the nation did not decrease as a result of the war.

A study of the three "curves" on Fig. 6 (the mining, farming and manufacturing efficiency) discloses many very significant facts, all of which I will not discuss now.

As to the reasons why manufacturing workers' efficiency ceased to increase after 1899, there seem to be three outstanding causes: First, the displacement of the 10-hour day by the 8-hour day; second, the increase in restrictive "rules" by labor unions; and, third, the great influx of "cheap labor" from Europe, most of which gravitated to the factories and mills.

Farmers' efficiency ceased its rapid increase in 1889, but it still continues to increase slowly.

Miners' efficiency has increased steadily and wonderfully. I attribute this mainly to the fact that mining is the one very large industry that employs professional engineers, to a great extent, both directly and indirectly, and is at the same time speculative enough to attract abundant capital and the best managerial brains. It is our mining engineering colleges that have trained such men as Herbert Hoover. It is the dazzling opportunities in mining that have attracted such brains as his.

Having secured the values of E (per capita efficiency) back to 1869, with great accuracy, it remains to approximate the values of E for the 10 years prior to 1869. This can best be done by studying the buying power of average wages in relation to the productivity of the average worker, to a consideration of which we now pass.

"Equated" Average Wages and Per Capita Productivity.—In order to compare the money wage rate in one year with that in another, it is necessary to convert actual money wages into "equated" money wages, that is, to express the wages in terms of the quantity of commodities that they will buy. This can best be done by dividing the average money wage of each year by the weighted average index price of commodities for that year.

The wage "curve" in Fig. 1, shows the relative daily wages for every year from 1859 to 1907, assuming that of 1860 to be 100 per cent. Divide the relative wage rate for any year by the actual index price for that year, and the quotient is the relative purchasing power of wages for that year. Thus in 1860 the relative wage was 100, which divided by 90 (the index price for 1860) gives 1.11 as the relative purchasing power of wages in 1860. Then for 1877, the average wage was 139, which divided by 87 (the index price for 1877) gives 1.60 as the relative purchasing power of wages in 1879. Since we have used the year 1879 as our 100 per cent standard for commodity prices, we must also use it as the 100 per cent standard for the relative purchasing power of wages. To do this divide the 1.11 (for the year 1860) by the 1.60 (for the year 1879), and we get 70 per cent, which is the ratio of the purchasing power of wages in 1860 as compared with 100 per cent in 1869. It will be seen that in Fig. 4, the "curve" of daily wages for 1860 touches the horizontal line marked 70. In like manner the other points on that wage "curve" were calculated.

In a similar manner the relative purchasing power of the average annual wages of all factory workers was calculated for every census year (1859, 1869, etc.) and for the intermediate years of 1904 and 1914; and the results are shown in the factory wage "curve" in Fig. 4.

The per capital efficiency curve (E) is also shown in Fig. 4. A study of the two wage "curves" and the per capital efficiency "curve" discloses a very close correspondence. The economic significance of this is that, on the whole, workers have been paid in proportion to what they have produced, and that this has held true for the 55 years for which data are available.

It will be seen that the relative daily wage "curve" (Fig. 4) is quite irregular. This is due mainly to the fact that commodity prices move up or down more rapidly than do wages. For verification of this fact, see Fig. 1, where it will be seen that money wages continued to rise slowly several years after the civil war ended, although the average price of commodities was dropping rapidly.

Since the relative buying power of wages in 1860 was practically the same as in 1869, it is safe to assume that per capital productive efficiency (E) was practically the same in 1860 as in 1869. Accordingly, on Fig. 6, I have plotted the "curve" of per capita efficiency back to 1859, assuming it to start at the level (80 per cent) in 1859 as it was in 1869, and dipping down to the level of 70 in the year 1865, following the trend of rising efficiency in the 10-year period of 1869 to 1879 also following the general trend of the daily wage curve of Fig. 4. While this method of deriving the per capital productive efficiency for the years between 1859 and 1869, is not as accurate as that for subsequent years, any error at worst can be only a small percentage.

We now have reliable values for E to use in my price formula for every year for 60 years. To secure the data for determining E constituted the major part of the problem which this article discusses, but I feel, that the results have abundantly justified the effort of securing them.

Engineers will see in this work only an application of engineering methods in the solution of a problem in political economics. I trust that readers who are not engineers will see also the great logical advantage of this method, over the ordinary methods—or lack of methods—commonly used by those who are discussing the causes of the high cost of living, to a final brief review of which we may now pass.

The Causes of High Prices.—If my price formula is correct, it must contain all the factors that have any marked effect upon average wholesale prices. If so, all coacting causes of changes in average prices must find their "resultants" in one of the four variable factors that appear in the formula; namely, total currency in circulation (M), rate of money turnover (V or T), total population (P), and per capita productive efficiency (E). Moreover, anything that does not alter any one of these four factors has no effect upon average prices of commodities.

Some conclusions that will startle many people necessarily follow from this last generalization. For example, it follows that extravagance in buying "luxuries" has no effect upon the average price of all commodities; neither do high taxes have any effect. I will discuss these, and other matters briefly at the close of this article.

The four variable factors in my price formula should be regarded as quantitative measurements of the resultants of all the psychological and physical forces that affect the average wholesale price of commodities. But, as above indicated, since retail prices, in the long run, are about 50 per cent in excess of wholesale commodity prices, it follows that my price formula is applicable also in determining the general levels of retail prices. It must be remembered, however, that although retail price "curves" follow the trend of wholesale prices, retail price changes are less rapid than wholesale price changes.

The outstanding causes of rapid price changes are two: (1) Changes in the quantity of currency in circulation (M), and (2) changes in the rate of money turnover (V). Population (P) changes but slowly, and per capita efficiency (E) is also a factor that does not change very rapidly for the better. See Fig. 6 for confirmation of this statement as to efficiency.

With 40,000,000 workers to be acted upon, with 40,000,000 habits rather deeply seated, with the inherited tendencies of countless millions of ancestors tending to hold the 40,000,000 to their relative incapacity and aversion to study, it is clear that no great change in their efficiency can be speedily effected, unless the entire industrial organization is completely disrupted, as it has been in Europe. A change of efficiency for the worse may be quickly brought about by revolution or war, but a change for the better is but slowly effected even in the most efficient of countries.

American industries have not been disrupted by the war, and there has been no decrease in per capita efficiency, hence we can look for no rapid lowering of prices from increased productivity. Now that the 8-hour day has become quite general, we may look for a resumption of the former annual increase in efficiency, say the 1 per cent annual increase that occurred during the 1899 to 1909 period (see Fig. 6). Eventually we may get back to the 2 per cent increase in annual efficiency that occurred during the period of 1879 to 1889; but we can hope for little better than this until all labor leaders teach their followers that the buying power of the average worker's income is dependent upon his productivity. Great Britain was fast losing her commercial supremacy before the war, because of the restrictive acts of trades unions; America is now in grave danger of a similar result, because of the growing power of labor leaders who are ignorant of economics.

How Far Will Prices Drop?—The immediate future offers no hope for much lower prices as a result of an increase in labor efficiency in America.

Population will increase about 1.5 per cent annually, and per capita efficiency will probably not exceed that rate (1.5 per cent) of increase. Adding these two percentages we have 3 per cent as the probable annual tendency to lower prices that may be expected during the next 5 or 10 years as a result of increased population and increased efficiency combined.

Currency will probably increase 8 per cent before the close of 1920, and thereafter is likely to increase about 3 per cent annually. An annual increase of 3 per cent in our currency will tend to raise prices 3 per cent annually; hence this 3 per cent rise due to M will offset the 3 per cent decrease due to P and E.

This leaves only money turnover (V) to which we can look for relief from high prices for many years to come. But we have already seen that a reduction of 20 per cent in the rate of money turnover will bring that rate back to the prewar rate. Hence we can look for a reduction of only 20 per cent in average commodity prices. This 20 per cent drop may occur within a year or it may not occur for several years, but it marks the probable limit of the decrease in average commodity prices for several years to come.

Since the index price for 1919 was 212, a reduction of 20 per cent will bring average prices down to 170, or 70 per cent above the prewar level. This is the probably lower limit to which average commodity prices will descend; but should Europe ship to America the $500,000,000 in gold that it is planned to ship this autumn, that alone will tend to send our average prices up 8 per cent, so that the year 1921 will have a price level of fully 175, even if the entire 20 per cent decrease in the rate of money turnover occurs within a year.

I conclude, therefore, that any commodities that can be bought at not much more than 75 per cent above the prewar level, will be bought at a reasonably low price; and that this will hold true for many years to come.

Probable Construction Costs in Future Years.—Having determined the probable lower limit of average commodity prices, we can now predict with considerable accuracy as to future construction costs.

When the general price level changes, because of an increase in money or in the rate of money turnover, each commodity tends ultimately to change in price to an equal degree. During a war period, the prices of textiles, steel, food and other things that are greatly needed for war purposes rise more rapidly and higher than the prices of commodities (such as brick, cement, etc.) that are not in such great demand. But after the end of the war, the prices of the commodities that have risen the most, fall ultimately to the average price level, whereas the prices of commodities that were below the average price level rise till they reach it.

The "Monthly Labor Review" of the U. S. Department of Labor gives weighted average index prices by months, back to and including the year 1913, not only for all commodities but for 8 different classes of commodities. Among these 8 are two classes that include building materials, namely, "Metals" and "Lumber and Building Materials." For the year 1919 the average index price of "Metals" was 160, whereas the index price of all commodities (see Table I) was 212. Evidently, then, metals will rise about 10 per cent above their 1919 level before they reach the 175 index price that I have predicted as the probable minimum average index price during the next few years.

The index price for "Lumber and Building Materials" averaged 190 in 1919; hence this class of materials may be expected to decrease in price not more than 8 per cent, to reach the 175 index price that I have predicted as the minimum during the next few years.

Such data make it clear to me that building material costs averaged about as low in 1919 as they will average for many years to come. Moreover it should be remembered that the labor of building construction constitutes 40 to 50 per cent of the total cost of construction (see the writer's Handbook of Cost Data). Wages in the building field have risen greatly, but will probably rise more. Here again attention should be called to the wage "curve" in Fig. 1, showing the rise in wages that occurred for many years after the close of the civil war in 1865. Ay slight decrease in the prices of building materials that may occur will be fully offset, and more too, I think, by the rise in wages during the next few years. Hence nothing is to be gained eventually by postponing building construction.

The same holds true of practically all construction, such as roads, railways, waterworks, sewers, etc., and for the same reason. Where a large part of the construction cost is the wages of common or unskilled laborers, the costs of construction will undoubtedly rise. Immigration has fallen off to almost nothing, and since unskilled workers are recruited mainly from immigrants, it is evident that the wages of unskilled workers will continue to rise, although they are relatively high already. There is little likelihood that America will again permit a million immigrants to come to this country annually, a million being the average rate for the 10-year period prior to 1914. The inevitable effect of reducing the supply of common laborers so greatly will be to raise the wages of those that we now have.

My inference from these facts is that it will be futile to postpone construction of any kind in the hope of lower construction costs. It will be many years before construction costs will decrease materially below the level of 1919.

Some Imaginary Causes of High Prices.—Among the imaginary causes of present high prices are: (1) Profiteering, (2) Extravagance, (3) Inefficiency of workers, (4) Scarcity of commodities in America, (5) High taxes.

"Profiteering," even where it exists, can not affect average prices, however much it may affect the prices of a given class of things. Profiteering merely serves to change the distribution of the total currency, but does not change the total. Profiteering does not change the total buying power of the nation, for that is measured by the product of the total currency and its rate of turnover. Profiteering diverts the currency into pockets and bank accounts that it would not otherwise have reached, such a diversion may result in a greater buying of certain commodities by the profiteers. But by as much as those profiteers increase the demand for the things they purchase, by an exactly equal amount there occurs a decrease in the demand for the things that would otherwise have been purchased had there been no profiteering.

The very same sort of reasoning holds good as to extravagance. Extravagance diverts money from the purchase of, say, construction materials, to say, diamonds and silks; but extravagance alters not one whit the total annual buying power of a nation.

Those that attempt to reason in the field of political economy are prone to reason falsely, because they think that what is true of one or many individuals must be true of a nation. An individual may grow wealthy by the accumulation of paper money, but a nation, never. Similarly the prices of certain articles may rise as a result of extravagance or of profiteering, but the prices of all articles can not possibly rise from such causes.

I have already shown that the alleged decrease in efficiency of America taken as a whole is purely imaginary. America never produced as much per capita as it produced in 1918 and 1919.

A general scarcity of commodities in America does not exist. This also is a fictional reason for high prices.

Scarcity of commodities in Europe affects average prices in America only in one of two ways: (1) By the shipment of gold to America, and (2) by increasing the rate of money turnover. It has done both; our currency has increased about 50 per cent since 1913, and our rate of money turnover has increased about 33 per cent.

High taxes have no effect on average prices, unless they cause a stagnation in industry. It is possible that this may yet occur to some extent, because the graduated income tax takes away a large part of the profits in business of a venturesome nature (notably mining) and therefore tends to a restriction of business enterprise. Also if high taxes lead to a permanent and large increase government activities of an unproductive nature, there results a lowering in productive efficiency per capita (the E in my price formula) and a consequent rise of average prices of commodities.

I might discuss several other popularly acclaimed causes of high prices, which are not causes at all, but this long article must be brought to a close. Before closing it, I will next give a concise deduction of my price formula.

Deduction of the Price Formula.—In a society prior to the introduction of banking, the money was "turned over" several times annually in the purchase of goods and in paying for services. But since any payment for a service merely furnishes the payee with money with which to buy commodities, it follows that the money is turned over a number of times annually in buying all the commodities produced annually.

The total number of units of commodities produced annually, multiplied by the average unit price, multiplied by the number of times the commodities change hands gives the total annual volume of sales where all that is annually produced is sold. This verbal statement can be compactly expressed by a formula, thus:

$$N \times W \times H = S.$$

In this formula,

N stands for the total number of units of commodities produced annually (the sum of the numbers of bushels of grain, tons of metals, etc.).

W stands for the average price in dollars per unit, or "unit price."

H stands for the average number of times the commodities change hands.

S stands for the total volume of annual sales expressed in dollars.

In a community having no banks or system of payment by checks or by barter, but in which all payments are in money, the total money multiplied by the average number of times it is annually turned over gives the total volume of annual purchases. This verbal statement may be expressed by a formula, thus:

$$M \times V = A$$

M stands for total quantity of money in dollars.

V stands for the average number of times that the money is turned over, or changes hands, during a year.

A stands for the total volume of annual purchases expressed in dollars.

But total annual sales (S) must equal total annual purchases (A), or $S = A$.

Since things that equal the same thing must equal one another, it follows that $N \times W \times H = M \times V$.

Dividing each side of an equation by the same quantity does not destroy the equality of the two sides. Hence if we divide both sides by $N \times H$ we get:

$$W = \frac{M \times V}{H \times N}$$

Expressed verbally this formula states that the average unit price af all commodities sold during a year is equal to the product of the money and the average number of times that it is turned over annually, in purchasing the commodities, divided by the product of the total number of units of commodities sold and the average number of times the commodities are exchanged for money.

This simple formula, which is frequently called the "equation of exchange," has long been known to economists. But it has been said to be of no practical utility because V (the average number of times money is turned over) and H (the average number of times that commodities exchange hands) are not ascertainable. Moreover, it has been contended that the existence of bank deposits against which checks are drawn, either makes the formula useless (since checks serve the purpose of money) or necessitates the deduction of a more complex formula. For reasons above given, I come to the conclusion, that the simple formula would serve even in a community where checking deposits are in use. Having reached this conclusion my problem became one of finding ways of measuring V, N and H for any given year.

Let us consider H first, H being the average number of times that commodities change hands before reaching the ultimate consumer. Except where speculation exists, commodities ordinarily change hands about 4 times, once when they pass from the producer of the raw materials to the manufacturer, once when they pass to the wholesaler, once again when they pass to the retailer, and finally when they pass to the consumer. Let us assume, for the moment, that $H = 4$, then the formula becomes:

$$W = \frac{M \times V}{4 \times N}$$

Now it is easy to see that if speculators were to intervene and sell the same product back and forth to one another several times, they would increase H. Let us say that they doubled H, the number of times the commodities change hands. Then coincidently they would double V, the number of times that the money is turned over. In general, then, any speculative buying and selling has no effect upon the average unit price in so far as the mere process of changing hands is concerned.

Let us next consider N, the number of units of commodities sold annually. To begin with, this is practically equal to the number of units produced, and the number produced depends upon the average efficiency of the people taken as a whole. Hence the number of units of product annually produced is equal to the total population multiplied by the number of units produced per capita. Expressed as a formula, this becomes:

$$N = P \times E$$

P stands for the total number of population.

E stands for the per capita number of units of commodities produced.

Substituting this value of N in the last formula above given, we have:

$$W = \frac{M \times V}{4 \times P \times E}$$

Let us now take some year, as 1913, as our standard for a 100 per cent index price. Then, as above shown in the discussion about index prices, we would divide the numerical value of W for 1913, into the numerical value of W for any other given year, say that of 1918. Since the factor 4 appears in the formula it would appear in the calculated unit price (W) for 1918 as well as for 1914; hence it will cancel out when the 1918 price is divided by the 1913 price to get the index price for 1918. Therefore it matters not whether we were correct in assuming the commodities change hands 4 times in reaching the ultimate consumer. Were they to change hands 3 times, the 3 would cancel out, and likewise for any other number of exchanges, provided the number is the same in different years. In any given country, the number of times that commodities change hands (except when speculation enters) is substantially the same from year to year. So we see that in deriving a formula for estimating index prices we can ignore the number of times that commodities pass from hand to hand, for we have already shown that speculative buying and selling has no effect on the price formula; and now we see that the number of times that commodities change hands in regular commerce has no effect upon the index price.

We are thus able to arrive at my general formula for calculating index prices, namely:

$$W = \frac{K \cdot M \cdot V}{P \times E}$$

In this formula K is a constant that is readily deduced thus: Ascertain the average values of W, M, V, P and E for a long term of years; substitute these averages in the formula and solve for the value of K. In this manner I found that K is so nearly equal to unity (1), that for all practical purposes the formula becomes:

$$W = \frac{M \times V}{P \times E}$$

This is the derivation of formula that we have discussed at such length.

Conclusion.—Turning to each of the 20 questions that appear at the beginning of this article we see that all have been answered definitely, except questions 2, 16, 18 and 19.

When will prices begin to drop?

The Bureau of Labor has just published index prices that show a halt, at least, in the rapid rise that has been in progress since 1915. Based upon this significant fact and upon the fact that our money supply has been stationary for 9 months, it is probable that average prices will begin to recede this year. However, the probable influx of $500,000,000 in gold before the close of this year will prevent a very marked recession in prices, and may cause a rise early next year, since the percentage increase in currency is likely to exceed the percentage decrease in the rate of money turnover.

Is it wise to lay in a large stock of goods or supplies now? If securable at a price not much in excess of 1.75 times the prewar price, yes; if not, no.

Can bankers safely lend money on buildings erected at present prices? Yes, for building costs will decrease but little in any event, and are more likely to increase somewhat for many years to come.

Will the costs of operating public utilities decrease so that prewar fares or rates will suffice? No. The level of commodity prices and wages will not descend permanently below one and three-fourths times the prewar level for many years to come.

50,000 Farmers Own Motor Trucks.—At least 50,000 farmers in the United States own motor trucks which they use on their farms. This is shown by a preliminary survey of the ownership and use of motor trucks by farmers undertaken by the Office of Farm Management and the Bureau of Crop Estimates of the United States Department of Agriculture. The figures on which totals for the nation and the several states are based were secured from approximately 35,000 selected crop reporters of the Bureau of Crop Estimates. These co-operators were asked to report the names and addresses of farmers they knew who own motor trucks for farm use. Pleasure cars and trailers for use with pleasure cars were excluded, and the reporters were asked not to take account of trucks which are used primarily for general custom hauling, or on regularly established routes. This survey can scarcely be considered a complete census for it is probable that in some localities the crop reporters were not acquainted with all the truck owners, but it is certain that a very large per cent have been listed. It is believed that in no State were less than 75 per cent of the trucks reported.

State Highway Officials Urge U. S. to Join World's Road Congress.—That the United States should accept the invitation of foreign countries to join the Permanent International Association of Road Congresses is the recommendation of the executive committee of the American Association of State Highway Officials to the Secretary of Agriculture. Secretary of Agriculture Meredith concurred in the action of the highway officials and told them he would recommend to the State Department that Congress be asked to authorize acceptance. The highway officials also recommended that the International Association be invited to the United States for its next meeting. In advising the secretary of the action of the State highway officials, Thomas H. MacDonald, chief of the Bureau of Public Roads, who is also a member of the executive committee said that the United States is the only civilized nation not now a member of the International Association. He saw many advantages in the United States becoming a member and he believed the other nations in the association would welcome an invitation to meet in this country next year.

Concrete Road Construction Methods on Contract No. 8 of the Du Pont Highway, Delaware

By GEORGE A. SHERRON.

The DuPont Road was originally started at the Maryland State line in 1912, but because of litigation that developed in connection with the securing of the necessary right-of-way, operations were not carried on extensively until 1915. At that time, a highway engineering department was organized, and 20 miles of the road were completed. Later 10 miles more were added, and then the entire project was turned over by Mr. T. Coleman DuPont to the State of Delaware for completion.

It is Mr. DuPont's idea to complete the road to Wilmington, Del., a distance of approximately 100 miles. The remainder of the road will be constructed under state supervision and in fact 18 miles of this have been completed to date, and there are an additional 18 miles under construction. As fast as the necessary right-of-way can be secured, the contracts are let for the continuation of the road, and it is estimated by 1920 the DuPont Road will have been completed from one end of Delaware to the other.

Some of the special features of the road are the straight alignment, the small number of curves and the flat grade. Every effort is being made to secure this straight alignment and deviations from it are only made where the obstacles are of such great importance as to render such a move necessary, or where the cost of right-of-way, and the subsequent construction would be prohibitive. In one instance, there is a tangent 12 miles in length; and in a distance of 35 miles there are only six curves. Most of the road has a width of 14 ft., but the section near Wilmington will be 18 ft. in width.

Coarse and Fine Aggregate Bins and Locomotive Crane in Operation.

Another very important item in connection with this road is the fact that very accurate records of type of construction, aggregate, cement, reinforcement, joints, weather conditions, temperatures, etc., and in fact, all details of construction, have been recorded and tabulated, and will furnish a very valuable contribution to our present knowledge of concrete highways.

The last section of this road to be completed, known as Contract No. 8, extends from Ellendale to Milford, a distance of 6½ miles. The contract for this work was let in 1918, but the work was not started until May 13, 1919. The road is of 1-course cement concrete, mixed in the proportions of 1 part cement, 2 parts fine aggregate, and 4 parts coarse aggregate, to which 10 per cent by volume of hydrated lime is added. This section is 14 ft. in width, and the average thickness is 7 in. No reinforcement or joints are used, except at the end of each day's run. At this point, a butt joint only is used and steel dowels or pins are inserted to prevent any possible change of grade.

All aggregates, cement, and supplies for this job, were con-signed to Lincoln City, which is located almost mid-way between Ellendale and Milford, and about 1½ miles from the road. The topography of Delaware is admirably suited to the use of industrial or narrow gage railway equipment for the transportation of aggregates and materials, and this method was selected by the contractor. The job was worked in two sections from this point and operations at the Ellendale end were started first. This provided an average haul of about 3 miles for the job.

The plant at Lincoln City, consisted of a locomotive crane, with a 1½-yd. clam shell bucket; bins for fine and coarse aggregate; a cement house; a small office and tool house; and the necessary track, switches, etc., for the operation of the industrial trains. The aggregates were unloaded from the cars by the crane and deposited in bins. When the bins were full, the aggregates were deposited on the ground in stock piles, adjacent to the bins, and when no cars were on hand, to be unloaded, the bins were re-filled from these piles. This of course meant a second handling of the material, but the additional cost is slight compared with the facility with which the material can be handled for shipment to the job and the expense of demurrage should the cars be permitted to accumulate in the yard. This the railroad companies would not permit. All things considered, the second handling could not be prevented unless immense bin storage were provided at a prohibitive expense.

Loading Fine Aggregate Into Batch Boxes.

Loaded Batch Box Being Transferred to Charging Skip by Means of Mixer Derrick.

All materials were transported to the work by means of an industrial railway, the equipment for which consisted of about 36 flat cars, each of which carried two batch-boxes, several platform cars for cement and tools, and two small locomotives. This, together with the necessary track, switches, etc., was rented or leased from the Koppel Industrial Car Co., of Koppel, Pa. The only criticism that could have been made was that some time would have been saved on the long hauls or when accidents occurred, had additional rolling stock been available. The batch-boxes were of steel, of the tip-over type, with a capacity of 28 cu. ft. Each train was made up of 15 flat cars, carrying 30 batches (an hour's run for the mixer), and a platform car carrying the necessary cement in bags.

At the railhead, the cars, each containing two batch-boxes, were hauled to the bins for filling, by means of horse power. The platform car upon which the cement in bags was placed was then loaded and placed in the rear of the train as made up. The train was then backed to the job, and upon arrival the entire train with the exception of the cement car and four of the aggregate cars was "kicked" beyond the mixer to a point where it would not hamper the finishing operations of the road. The engine then left the balance of the train at the machine, and returned to the siding which was about a two days' "run" from the mixer, where it picked up the "empties" and returned to the railhead, passing the other train on the way. The cars were hauled down to the mixer as needed, by horse power, and the empties were hauled to the siding in the same manner.

Concrete Mixer in Operation.

The mixer used on this job was a No. 18E Koehring trunk line paver, equipped with boom and bucket distributer; power operated derrick for transferring the batch-boxes from the cars to the loading skip, power operated charging skip, automatic water measuring tank, and caterpillar traction. This latter feature was of much value as a time saver. No planking was necessary under the wheels and the moves were made with practically no loss of time.

The specifications required that the concrete should be mixed for 1½ minutes, and this was rigidly adhered to. The power operated derrick and the boom and bucket system of distribution enabled the machine to turn out 30 batches per hour, or 18 cu. ft. of mixed concrete every 2 minutes.

The amount of labor required around this type of plant was very small. At the front of the mixer, two men looked after the cement, and two others attached the derrick bail to the batch box, swung box into position over the charging skip, dumped contents into the skip, and then swung empty box around to the car. While dumping the box, the cement men quite frequently assisted them, although it was not necessary. A mixer of this type required three men to operate it, an operator, a fireman and a derrickman for the power derrick. Behind the mixer there were three men placing concrete; two on the templet; and two rolling and belting. This is a very small crew for a machine of this size. The transportation required the services of five men, two enginers, two firemen and an extra man. This was a very small crew for this work.

All track was kept off of the subgrade; in fact, no traffic of any sort was permitted on the finished grade. This makes a very satisfactory operation, as the finished grading operations can be carried far in advance of the construction, without fear of having to perform some of the work over again. It must be kept in mind, however, that this method is not applicable to all construction operations; that the natural conditions must be favorable; and that the job must be extensive enough to support the large initial outlay for the industrial plant necessary.

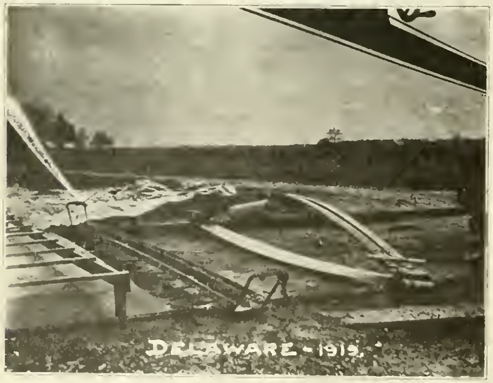
Heltzel steel sideforms 6 in. in depth were used. The forms were oiled after being placed in position. This oiling prevents the concrete from adhering to the forms and results in a better surface at the shoulder where the concrete has been in contact with the form. To insure a true subgrade a subgrade templet was drawn between the forms ahead of the mixer and all variations were removed, either by cutting off or filling in, so that the finished grade should not vary more than ¼ in. from the true grade.

After the concrete was deposited on the subgrade it was leveled off with shovels and then "struck off" with the Delaware type of templet, which consists of a 10-in. steel channel, used web side down and of a length 1 ft. in excess of the width of the road. This templet is bent to conform to the curvature of the road and U-shaped handles of 1-in. round iron are riveted to each end. A 4-in. x 4-in. angle is also riveted along the channel to stiffen it and help preserve the curvature. The weight of the templet is approximately 400 lb.

The templet is handled by two men who drag it ahead about 6 in. at a time, first on one side and then the other. The heavy templet forces the stiff mass of concrete into position and compression is secured without the tamping effect.

The amount of water in the concrete was watched very carefully and every effort was made to secure a semi-plastic mix, or a concrete of a consistency that is just workable, and without an excess of water. After the concrete had been "screeded" or "struck" off it was rolled with a 100-lb. roller 6 ft. long and about 8 in. in diameter. This was to squeeze out the excess water, and the operation was usually repeated two or three times. The surface was then finished with a heavy rubber belt 10 in. in width and 1 ft. longer than the width of the road. The ends of the belt were fastened to a 1-in. x 10-in. dressed board 12 in. to 18 in. longer than the belt.

This forced the board into the form of a bow and in this position it was easily handled, and the belt kept tight. In this position it does not blister and stretch unequally, as do most belts not protected in this manner. After the first belting the surface of the concrete is covered with fine wavy lines, caused by the belt being drawn back and forth. A second belting eliminates these lines as it is drawn straight to the front, and the surface of the road is left with a perfectly smooth finish. The templet and belt were developed by the Delaware Highway Department after some study and experiment.



Bow Belt, Steel Template, Roller and Rack for Supporting Canvas Protection for Freshly Laid Concrete.

The concrete was cured in the regular manner with an earth covering kept wet for about 14 days, and was opened to traffic at the end of 30 days. The necessary water for construction operations was secured by driving wells adjacent to the right-of-way, and pumping to the work. The aggregates were carefully tested and the inspection was very complete. The Delaware State Highway Engineer is Charles M. Upham, and the road was constructed under the immediate supervision of Clarence Gale, engineer of construction for Delaware. The contractor was Frank L. Cohen, of Buffalo, N. Y.

Methods of Maintaining Water Bound Macadam at Hartford, Conn.

Approximately 73 per cent of the street mileage of Hartford, Conn., is surfaced with waterbound macadam. Altogether there are about 100 miles of this type of pavement distributed throughout the city. Under the methods employed the cost of maintaining this mileage has not increased in recent years more than the increased cost of labor and materials in spite of the increase in motor vehicles. An interesting description of the maintenance methods was given by Mr. Leon F. Peck, Superintendent of Streets, of Hartford, in a lecture delivered Jan. 9, before the post graduate students in civil engineering at Yale University. The matter following is abstracted from the paper:

Surface Patching.—Surface patching as here considered involves applying the materials to the surface of the depressions without cutting out or other special preparation. An organization should be maintained for giving such prompt attention that most of the work will be devoted to depressions of only ½ in. to 1 in. in depth. Such thin layers of waterbound crushed stone cannot be satisfactorily held in place under motor traffic. A tar or asphalt binder is needed.

Very slight depressions can be satisfactorily brought to grade by sweeping them clean, spraying a light coat of tar or asphalt patching material and covering with ½ in. crushed stone or clean gravel. Deeper depressions and ruts should be cleared of loose material and the deeper than 2 in. filled to within 2 in. of the top with stone tamped solid, and completed with a bituminous concrete, or with crushed stone bound with bitumen applied by the penetration method and tamped or rolled.

For surface patching I prefer refined tars ranging in specific gravity from 1.17 to 1.24 using the lighter grades for the very thin patches, and for all surface patching done after the season advances into colder weather.

The necessity of heating this material is an inconvenience but is generally warranted, especially for the thinner patches. Deeper depressions of more than 1 in. in depth can be satisfactorily and more conveniently filled with a bituminous concrete mixed cold and applied cold. Here I prefer asphalt on a combination of asphalt and tar having a specific gravity of from 1.12 to 1.17. The amount of bitumen ordinarily will vary from 5 per cent to 8 per cent by weight of the amount of stone. A greater percentage will cause the patch to creep or crowd in the direction of the majority of traffic and mound up on the more stable original macadam at the edge of the depression filled. In other words, too much bitumen surely results in a wavy pavement.

After the patching squad becomes experienced it is safe to depend on their judgment to determine the amount of bitumen being poured in the penetration patching as it is rather impractical to take time to first determine the percentage required and then measure it.

Increasing the size of the stone as the depth of the depression increases up to a reasonable limit materially lessens the liability of crowding and creeping.

The above described use of bitumen for patching waterbound macadam is contrary to the theory that patches should not be made with materials having different density or different resistance to wear than the surrounding original pavement. The method, however, has proven practical in repairing a pavement now called upon to carry a type of vehicle for which it was not originally intended. The general use of tars, and road oils having an asphaltic base as a dust layer or surface treatment tends after all to produce a surface on waterbound macadam quite similar to the bituminous patch. Thus the exposed surfaces become more or less homogeneous.

Body-Patching.—This term may be applied where repairs are made by first cutting out the depression to a depth of about 4 in. or more with nearly vertical edges. I do not recommend a bituminous concrete patch of this depth in a waterbound macadam pavement. A very durable waterbound crushed stone patch of this depth can be made. Likewise a crushed stone patch surfaced with bituminous concrete as before mentioned.

Another way of getting over soggy ground is to increase the depth of macadam from 8 in. to 10 or 12 in. If dry weather conditions have permitted the proper keying together of the stones in the bottom course it is well to fill this course with stone screenings lest a rain brings about a condition of subsoil whereby it will enter the bottom course and lubricate the stone until they are displaced when rolling the top course.

An 8 in. to 10 in. telford makes an excellent foundation if properly laid. Where telford is used the crushed stone top can be reduced to a thickness of about 4 in. Where heavy soils requiring special foundation are encountered a drainage trench should be opened through the shoulders and filled with crushed stone at intervals of from 50 to 200 ft.

A drain having its trench filled with coarse gravel or crushed stone to act as a cut-off trench between the road bed and any high ground sloping towards it is, at least for a few years, especially effective in preventing the underground seepage, which, may continue for some weeks after a rain, from entering under the road bed.

When the breaking through takes place the dirt subgrade and macadam stone become so mixed that the whole mass should be excavated to a greater depth than before and refilled with new macadam.

Sometimes the break is over a spring. Such a place surely should be drained. If these springy places are confined within a reasonably short radius a well can be excavated in the center three to six feet deep and filled with gravel from which a pipe drain is laid to a direct connection with the sewer or to the nearest outlet that the topography may furnish.

Maintenance by the bituminous paint coat treatment is practically essential on thoroughfares not too congested to permit moderately fast motor car traffic. This treatment is also a dust preventative and will be considered under the heading "Dust Prevention."

When Waterbound Macadam Should Be Replaced by Better Pavement.—To determine when a waterbound macadam should be replaced by an improved pavement is largely an arbitrary matter. When it can be shown that the cost of upkeep has become substantially as much as the interest would be on an investment for a more durable pavement, then the reason is sufficient. This condition, however, seldom exists.

According to my arbitrary rule a change should be made, if the traffic is mixed when it amounts to 800 to 900 vehicles per day and often earlier according to such conditions as, police control of speed; weight of vehicles; extensiveness of immediate repairs needed; condition of foundation; character of abutting property, etc.

Cost of Maintaining Waterbound Macadam.—The cost of labor, materials and maintenance of equipment for repairs including all resurfacing and renewals averaged over 1,321,000 sq. yd. of Hartford's waterbound macadam for the 10-year period ending March 31, 1916, was $0.0343 per square yard per year, and for the 3-year period ending March 31, 1919, it was $0.0435 per year. The cost has increased in about the same proportion as that for labor and materials.

Dust Prevention Methods and Costs.—Three agencies will be considered: Water, oil and calcium chloride.

On horse-drawn traffic streets, water is satisfactory and helps to maintain the effectiveness of the natural binder. Water becomes more unsatisfactory as the number of self-propelled vehicles increases. The modern traffic makes it necessary from a dust prevention standpoint that the street surface does not become dry between sprinklings.

It is practically impossible to organize to meet this requirement. To do it, the organization must be three times larger on some days than others on account of the rapid evaporation under certain changes in atmospheric conditions.

An attempt to meet the requirement by using an excess of water is annoying to the motorist with a clean car, and is detrimental to the street as indicated to you when we discussed repairs. Water is especiallly detrimental to bituminous pavements. The cost of water sprinkling for the season with a charge for water of 2 ct. per lineal foot of street was, for several years about $0.026 per square yard of area to be kept sprinkled. Higher rates for wages and teams increased the cost in Hartford for the fiscal year ending March 31, 1919, to $0.0363 per square yard.

My practice is to use asphaltic oils for macadam, because of the beneficial results from a maintenance standpoint of the remaining bitumen after the more volital constituents have evaporated.' The maintenance benefit exists in a greater or lesser degree whether the mat is obtained immediately by one application of ½ gal. per square yard of 60 per cent to 70 per cent asphaltic oil covered with sand or whether it is obtained gradually by many applications of 1/5 to 1/10 gal. per square yard of 40 per cent to 50 per cent asphaltic oil without sand covering distributed over one or two seasons. These oils are often less satisfactory from a maintenance point of view on gravel roads, especially if the aggregate is fine. The oil prevents sufficient moisture from entering to bind the fine particles, therefore they separate and scaling takes place.

In the early and late parts of the season it is sometimes too cold to successfully apply asphaltic oils.

Non-asphaltic oils can then be used. They should be used sparingly on streets still having considerable asphalt from previous applications, in order that it be not cut back too much. A certain amount of livening up of the old asphalt is often beneficial, however, both from a durability and dust prevention standpoint.

For the past 7 years, excepting the fiscal year ending March 31st, 1919, water bound macadam has been oiled. Approximately 90 per cent of the amount used was the 40 per cent to 50 per cent asphalt oil. It was applied under pressure usually in quantities ranging from 1/5 to 1/10 gal. per square yard. Only one side of a street was done at one time. Oil was not covered with sand excepting where it failed to penetrate quickly. The number of applications varied from one to eight. Macadam street area listed for dust laying for the season of 1919 amounted to 1,501,560 sq. yd., all of which was finally oiled. About 25 watering carts were put on April 1, and gradually retired as the oiling took their place. It required about three months to retire them all. Oiling continued until November. Under this plan the total amount of oil used averaged about 3/10 gal. per square yard. Most of the oil cost $0.052 per gal. f. o. b. cars Hartford.

The entire cost for the season of labor, teams and materials including watering averaged over the entire area was $0.0433 per square yard. Generally the streets were not swept for their entire width. Most of them having sufficient motor car traffic to keep the center fairly clean, by blowing the particles of dirt to the curb where they are gathered by the regular street cleaning force.

In reference to immediately securing a bituminous mat, if the streets are properly selected either a 60 per cent to 70 per cent liquid asphalt or a refined tar having a specific gravity of about 1.16 spread cold on a swept surface and covered with one layer of ½-in. crushed stone followed with enough coarse sand to fill voids and absorb the surplus bitumen will make a very durable protective mat. Covering with sand only will also be satisfactory.

The asphalt mat has some advantages over tar in the city work where fine particles of dirt are constantly being brought on it. It has been my experience to receive more dust complaints from the tar surfaces than from the asphalt surfaces, due no doubt to the oxidizing or crusting over of the tar surface exposed to the air, thus it does not absorb and weigh down the dirt particles in the way that a more oily mat does.

For this work the macadam should have good surface drainage and be in good condition. Heavier oils that require heating are also successful. They are more expensive to apply but perhaps a little more durable. If either treatment is to be applied to new or newly resurfaced waterbound macadam, experience indicates that time enough should first elapse to permit traffic to practically wear away the mat of cemented stone dust that is usually left on a new surface due to the practice of using a surplus of the stone dust binder, otherwise the application of the bitumen seals the surface, keeps out the moisture, and being too heavy in itself to penetrate the cemented stone dust, permits drying and disintegrating of this layer between the bituminous flush coat and the body of the macadam. This results in serious surface scaling followed by ever deepening cup holes in the street surface. Too much bitumen in flush coats results in a wavy surface the same as in bituminous patching. Brooming the surface bitumen ahead as fast as applied prevent it. In other words paint the macadam instead of flushing it thus the term "paint coat" becomes more appropriate than "flush coat."

Bituminous mats are not successful on waterbound macadam in a commercial or trucking district, if horses or steel tires are used.

The tests are usually made for specific gravity. Flash and burning points, loss on heating 5 hours at 325° F.; asphaltic residue of approximately 100 penetration; character of residue; bitumen soluble in carbon tetrachloride or carbon bisulphide and fixed carbon.

Calcium chloride is cleaner and therefore less objectionable than the asphaltic oils when first applied. It can be dissolved in a sprinkling cart as it is being filled and then applied in a liquid form. Usually it is more convenient to use in the granular form, then it can best be spread with a fertilizer spreader at the rate of from 1 to 2 lb. per square yard. Gravel or macadam with considerable fine aggregate is suitable for it. It is more practical to use it on shaded or damp surfaces. One application at the rate of 1.2 lb. per square yard on 5 miles of gravel park drives having an area of 52,800 sq. yd., cost for material and freight $0.0140 per square yard and for cartage and applying $0.0016 or a total of $0.0156 per square yard. It must be borne in mind that these were shaded drives and not subject to heavy traffic. Therefore it is reasonable to expect the cost of thorough dust laying by the calcium chloride treatment to be not less than four times greater on public thoroughfares exposed to the sun.

Hints for Road Grading

Useful suggestions on equipment for highway grading were given by Mr. Richard Hopkins, in a paper presented last February at the annual convention of the American Road Builders' Association. The following is taken from the paper:

Jobs where the excavation exceeds 5,000 yd. per mile, and where a large proportion of the hauls are long, will generally call for a steam shovel. Where hauls are short and cuts small, scraper work will continue to hold first place. No grading job is complete without wheelers, drag-scrapers, fresnos, and at least one road machine.

Each of the three types of scrapers is more economical than either of the others under certain conditions, and for the small extra investment in plant it is foolish to be without at least a few of each one of the three kinds. Most contractors have in the past erred on the side of having their wheelers too large and their drag scrapers too small. The fresno of a 4-ft. width is the proper size for the average job. In case of shovel break-down, the teams can be put on scrapers until shovel is repaired. The road scraper is the most maligned, and the most neglected grading tool we have. A good operator is essential, and with one, much good finishing work can be done cheaper than by any other method. There is a big range of sizes available, so it is an easy matter to choose the one best suited to the particular job.

It is advisable to carry rough grading and finished grading along together, as the latter can always be done more cheaply while the dirt is mellow. Specifications are growing more stringent in the matter of rolling in thin layers. This requires a big labor expense on the dump, especially with steam shovel work. A team on a 4-ft. fresno will take the place of six men on the dump, and spread the dirt evenly for the roller. In this connection it is well to remember that aside from a steam roller nothing has been found that equals the compacting effect on a fill as horses tramping over it.

The rotary grader has been on the market only a short time, but large capacity and cheap costs have been reported. It works rapidly in loam or gravel, and cuts accurately to grade. It also cuts old macadam readily, and a stone screening attachment can be provided if a contractor desires to save the old crushed stone.

The old time rooter plow and scarifier are tools that will always be used when a small amount of old macadam is encountered. Most plow companies now make a heavy mold board plow with a narrow cut that is more successful in real hard pan than a rooter plow.

In shallow cutting with a steam shovel on old macadam, it will generally be found best and cheapest to cut a few inches below grade, and dump every third or fourth dipperfull behind the shovel for the fine graders to bring the subgrade back to the correct elevation. Where a roller is fitted with a scarifier attachment it is sometimes found that a lot of expensive hand work can be saved by its use.

Can We Afford to Delay Road Improvement?

By H. J. FIXMER,

Paving Engineer, Chicago.

While the good roads movement gathered great momentum in the past few years it is now a serious question whether enthusiasm will soon subside, due to the rapid increase in the cost of construction. Until recently it was difficult to initiate extensive road building programs, due to the average man's inability to understand the great value of road improvement. Now it will be difficult to convince him that road building should go on when the cost averages from two to three times the cost prevailing a few years ago when the plans were originally approved.

Road building will be very much retarded unless the authorities can be convinced that improved highways are economically necessary at this time. As a general rule, it is wise for the government to delay public works when prices are high and to proceed when prices are low in order to stabilize market conditions and give employment to labor. This is right where cost is not justified by either economy or expediency. Indiscriminate road building is not advisable at this time; but a proper investigation should be made of any given road project before deciding to postpone its improvement.

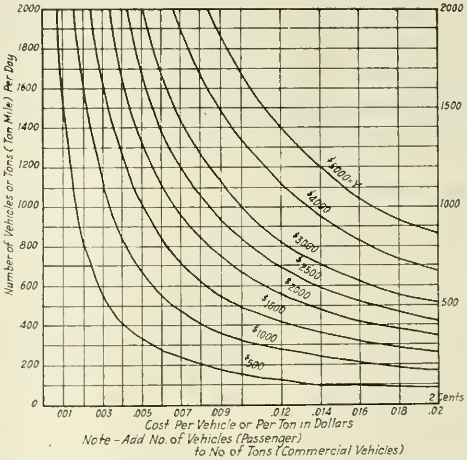


Fig. 1—Diagram Showing Cost Per Vehicle or Per Ton-Mile, Based on Daily Traffic, for Roads or Pavements of Various Annual Costs.

Considerable road building is necessary at this time to connect and make available many existing improved roads. The increase of automobile and motor truck traffic requires that additional traffic ways be made available for use. In order to persuade the taxpayer, the motor vehicle owner and the responsible authority that road work should proceed it will be necessary to marshal all our facts and figures and thus prove, in a crude way perhaps, that we can not afford the expense or economic loss of the unimproved road. Having proved this, the question remains, how much can we spend to get results commensurate with the anticipated or demonstrated economies. About a year ago the writer prepared some diagrams on the economies of road construction which he believes will prove of interest at this time.

Table I shows the relative cost per ton—mile or vehicle—mile on various classes of roads. This table is based on the relative average speed (and increased loads) permissible as a result of paving, and does not include wear and tear or other costs. These costs are about constant per hour traveled. The table is designed simply to give a comparison of the cost to traffic of the different road surfaces. As such it is fairly reliable.

TABLE I.

Class of pavement.	*Speed of tonnage miles per hour (averaged)	†Cost per ton-mile in cents.	Speed of passenger vehicles.	**Cost per vehicle mile in cents
First-class surface (asphalt-concrete-brick)	20	10	30	2
Bituminous macadam	14	15	25	2½
Gravel	10	20	20	3
Graded earth	8	25	15	4
Bad or neglected road	6-4	30-50	10	6

*Speed of tonnage decreases with increased load or tonnage carried.

†Cost per ton-mile based on $2 per ton per hour traveled.

**Cost per vehicle-mile based on 60 ct. per vehicle per mile traveled. Assume traveling time to equal 5 hours (net) per day.

It is well known that an improved road realizes an appreciable saving over a bad or inferior road, but the value of this saving in the aggregate is seldom understood. From Table I the unit saving per ton-mile or vehicle-mile can readily be determined by taking the difference between the costs shown for the types of road compared. Thus a first class road will show a saving of 1 ct. per vehicle-mile or 10 ct. a ton-mile over a gravel road. These are only averaged figures, too high in some cases and too low in other cases.

The diagram (Fig. 1) shows the unit cost per vehicle-mile or ton-mile based on daily traffic for roads or pavements of varying annual cost. For convenience the ton-mile is here considered equal to a vehicle-mile. Annual cost is used as it is the only rational basis for comparing pavement worth.

Knowing the saving per vehicle-mile or ton-mile, the amount of daily traffic to justify a given or assumed annual cost of road per mile, is quickly determined.

Annual traffic year is assumed at 300 days.

Let $X =$ No. of vehicles passing a given point per day.

$w =$ No. of tons passing a given point per day.

$y =$ Annual cost of improved road or pavement.

$z =$ Cost per vehicle or per ton in dollars.

$m =$ Saving per passenger vehicle per mile per day } See

$n =$ Saving per ton per mile per day. } Table I

Fig. I is based on the formula: $z = Y/300\,x$ or $Y = 300\,xz$.

Fig. 2 is based on the formula: $y = 300\,mx = 300\,nw$.

In either diagram the vehicle-mile must be added to the ton-mile to secure the correct total. A very simple traffic census will give the total number of vehicles or tonnage passing a given point. All empty commercial vehicles are classed with passenger vehicles. The annual cost (Y) is the sum of three items: interest on first cost, cost of repairs and maintenance, and amount to cover depreciation or pay for renewing the road at the end of its practical life.

Knowing the first cost per mile of the completed road, the interest, usually taken at 5 per cent, is easily determined. The annual cost of repairs and maintenance must be secured from past records or very carefully assumed. It should be borne in mind that as the traffic increases the cost of repairs and maintenance increases, and the life of the surface and road structure is reduced. The amount to add annually to cover depreciation or sinking fund is a function of the first cost, rate of interest and the estimated life. This can be secured from tables, or computed from the formula:

$$A = \frac{I}{(1+I)^{N-1}} \times C$$

$I =$ Being rate of interest.

$N =$ No. of years, or life.

$C =$ Total first cost.

The number of vehicles or tons per day must be carefully determined. It should be based primarily on a brief census, but increased to cover estimated traffic at the end of say five years. As a rule graded earth is satisfactory for less than 200 vehicles per day. Gravel for less than 500 vehicles per day and Bit. macadam for less than 800 vehicles per day.

TABLE II—APPROXIMATE RATIO OF ANNUAL COST TO FIRST COST.

Rank.	Class of pavement.	Ratio.
4	Improved earth	.20
3	Gravel	.15
2	Bituminous macadam	.12
1	Concrete	.09
1	Brick	.07
1	Asphalt	.06
1	Stone block	.05

Approximate ratio of annual cost per mile to first cost per mile is given in Table II. These figures are for normal traffic and are only roughly approximate. A careful estimate made from records and experience is to be preferred and is of course more convincing. In comparing the cheaper forms of road construction it must be remembered that the increase of traffic increases the cost of repairs, and shortens the life, which, of course, rapidly increases the annual cost (Y).

With the above data at hand it is now possible to show the approximate value of road improvement. Let us assume a road is to be built to accommodate 500 vehicles and 100 tons of traffic per day. Assuming that the present road is an average earth road we find from Table I that a first class road will save 4 — 2 = 2 ct. per vehicle-mile and 25 — 10 = 15 ct. per ton-mile.

From the diagram (Fig. 2) we find that 500 vehicles saving 2 ct. (m) will allow an annual expenditure of $3,000. Adding to this the saving for 100 tons carried, (N = 15) which from Fig. 2 is $4,400, we get a total annual saving of $7,400.

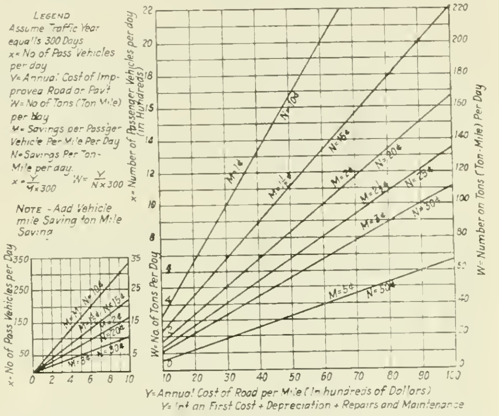


Fig. 2—Diagram Showing Saving Effected by Improved Roads.

A concrete pavement, let us assume, will cost at this time $40,000 per mile complete. The annual cost, as shown in Table II would be approximately $3,600. Carefully estimating the annual cost (to be more exact and convincing) we find:

Interest at 5 per cent	$2,000
Annual cost of repairs	50 150
Sinking fund (20-year)	1,200
Total	$3,400
Saving to traffic	7,400
Annual amount saved to public	$4,000

Where the traffic is greater a greater saving can be shown. However, we must consider this saving (or annual loss) with the possibility in the near future of a decrease in first cost. If the amount of saving to traffic can be shown to exceed 15 per cent of the first cost of construction it is believed the work should go on.

From the Diagram (Fig. 1) for a combined traffic of 600 tons and vehicles per day, and a total annual cost of $3,400, we find the cost per unit vehicle or ton (both here considered equal) to be .0185 dollars or less than 2 ct. Thus, for an average through traffic road, notwithstanding "high" prices, it is seen that road building justifies itself to a measurable extent.

Figure 1 is of general use to convince the tax payer the economy of the improved road. In fact the argument is as old as the first improved road. The original roads in this country were improved by private parties who were permitted to charge a toll. The toll charge was supposed to be less than the saving to the user over the cost of using the unimproved road. As traffic increased the toll charge could be lowered. When traffic became too great the tolls were abolished, for the delay and cost of collection were more costly than the warranted charge.

If it were true in the old days, when traffic was slow and certainly carrying light loads, that a toll charge was economy and willingly paid, how much more true it must be today that traffic is willing to pay a charge. Instead of assessing the traffic directly we permit it to pay its share in license fees and in reduced charges for hauling. The cost of haulage is added to the cost of goods. Any saving effected is expressed in lower prices which, of course, benefit everyone. The taxpayer is asked to return a part of the saving which he, in common with others, receives, or will receive, in the form of slightly increased taxes, or in financing by bond issues.

Any individual motorist will agree that an improved road is easily worth 2 ct. a mile to him, because of the comfort, time and wear saved. Likewise the truck owner is satisfied of the economy, if not necessity of road improvement. An improved road is easily worth 10 ct. a ton hauled to him. In fact an increase in license fees is warranted on the basis of this showing.

Having convinced the two classes of road users, and knowing the traffic to be accommodated on the given road, the diagram (Fig. 2) can be referred to, to show the annual economic loss which could better be applied to realize permanent and increased savings to the community. If the matter of road improvement be attacked from this angle it is believed that the authorities and the people can be convinced that work should go ahead in many cases, for the reason that it is costing us too much to postpone action.

Engineering Society Endorses Herbert C. Hoover for President of United States

The Northwestern Association of members of the American Society of Civil Engineers on March 12 adopted resolutions endorsing Herbert C. Hoover for president of the United States, and urging that engineering bodies unite to form an organization to further his candidacy. The resolution follows:

Whereas, The Northwestern Association of Members of the American Society of Civil Engineers believes that our most important problem at this time is increased production and service in all lines of industry to provide for our own needs and to render necessary assistance to others. This will require a general survey of our national resources in order to provide proper methods for developing and economically conserving those resources; and,

Whereas, Herbert C. Hoover is a man of international reputation as an executive with administrative abilities of the highest type and order, particularly fitting him for dealing with the serious economic problems of reconstruction now confronting the American people; and,

Whereas, Mr. Hoover's reputation for strength of character and for integrity of purpose can be depended on to give the nation an honest and efficient administration free from partisan politics; therefore, be it

Resolved, That the Northwestern Association of Members of the American Society of Civil Engineers, in meeting duly assembled, endorses Herbert C. Hoover for President and solicits everybody, but more especially the engineering bodies of the United States, to join with it in forming an organization to further the election of Mr. Hoover and in such other activities as will insure the nation's affairs being handled on an efficient and non-partisan basis; and be it further

Resolved, That copies of this resolution be sent to all engineering organizations and technical journals throughout the United States and urge that all proper steps be taken to accomplish the election of Herbert C. Hoover for President

Emergency Dimmers for Truck Lamps.—The cruising radius for motor trucks is constantly increasing and frequently the drivers are called upon to make deliveries in cities or towns where local ordinances demand a special kind of lamp dimmer, differing from that which the regulation at home requires. Sometimes this causes a lot of trouble for the driver, who must find some means of keeping within the law. In some cases, according to a monthly bulletin of the Service Truck Co., it is possible to use mud, and by smearing it on the glass, the light is dimmed to satisfy the most exact guardian of the peace. Graphite, or some other substance that makes a greasy smear, also furnishes an excellent emergency dimmer.

Sand Aggregate for Concrete Base and Pavement*

By P. L. BROCKWAY

City Engineer, Wichita, Kan.

A large territory in the western slope of the Mississippi River basin is practically without rock which is at all suitable for use in concrete pavement and barely possible even in the construction of concrete base.

French coefficients of 1.6 to 5 in various ledges of quarries which form the only available source within a reasonable distance are not uncommon. For this reason, soft, chalky limestone of this lack of toughness has been extensively used in making concrete base for pavement. The usual mix has been 1:3:6 with crusher run stone passing 1½-in. screen and retained on ¼-in. Base depths vary from 4 to 6 in. in most cases.

In the fall of 1917, a drastic embargo forbidding the shipping of paving materials stopped the supply of even this rock leaving a large amount of streets and roads in a torn up and impassable condition. Even now delays and embargoes make any arrangements which depend on rail shipments of even a few miles, most uncertain.

Partially offsetting the lack of rock is the abundance of sand carried by the rivers, past and present, flowing down from the Rocky Mountains. Bank sand of good quality is found in many places. River sand is inexhaustible in the Missouri, Platte, Kaw and Arkansas Rivers and many of their tributaries. Pumps and dredges are in common use on these streams. Not all the sand is good, depending on conditions of flow under which it is deposited, but good sand is available in all of them.

As a war time measure, many contracts were completed in the early winter of 1917 by constructing paving base with sand and cement, instances having been reported in which the mixture was as lean as 1:6 using sand practically all of which passed a 10 mesh sieve and making the base as thin as 4 in.

The city of Wichita is located at the mouth of the Little Arkansas River at its junction with the Arkansas River. The Little River sand runs coarse. A pump operating about five miles from the mouth regularly furnished sand, of which 15 to 20 per cent is retained on a ¼-in. screen. This gravel is nearly all granite, some shale and quartz. It is subject to the same objection as rock, so far as the city pavements are concerned, that of car shipments, and is furthermore sandwiched with clay seams which develop tough balls under the action of a pump.

For a mile above the mouth of the Little River the Big River runs nearly due east after making a right angle turn from a south direction of flow. The prevailing winds during the season when the river is dry are from the south and southwest. These winds have piled high dunes of "blow sand" on the east bank of the north and south portion of the river. This fine sand is remarkably clean and sharp. About 35 per cent passes an 80-mesh screen and practically all passes 40-mesh. Large numbers of similar dunes lie along the river where wind conditions have been favorable.

Sand in this locality which is easily available has the following screen analysis:

Through ¼ in.	Retained on ¼ in.	Per cent.
.....	.....	6.25
No. 6	No. 6	5
No. 20	No. 20	38.75
No. 30	No. 30	20
No. 40	No. 40	10
No. 50	No. 50	15
.....	.....	5

Percentage of voids of this sand is found by a number of tests to be very close to 28 per cent.

Calculations to determine the amount of cement possible to use with this sand without making concrete more expensive than by using rock at local prices are as follows:

	1:3:6 rock mixture.	Sand and cement.
Rock on track	$2.24	$0.00
Delivering rock	1.25	00
Sand delivered	.68	1.50
Cement delivered	2.50	5.37
Labor, mixing and placing	1.40	1.20
	$8.07	$8.07

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*Abstract of a paper presented at the last annual meeting of the American Society of Municipal Improvements.

The sum of $5.37 at $2.50 per barrel will buy 2.15 bbl. cement or 8.6 cu. ft.; 8.6 cu. ft. per cubic yard allows 1 part cement to 3 1/7 parts sand, not allowing for any increase in volume of the sand on account of addition of cement. Because of the surplus of cement in this mixture over that necessary to fill the voids in the sand and because of the practical difficulty in obtaining a mixture of sand of this odd small fraction, 1 to 3½ was selected for experimentation.

With this revision the cement necessary per cubic yard of concrete becomes 1.93 bbl. worth $4.83 or a total cost of $7.52 per cubic yard for concrete in place. This cost has been proven very nearly correct for good working conditions on 6-in. base by actual experience this season and to be about 20 ct. per cubic yard too low on an average where 5-in. base is laid.

Small beams were then made of identical size under identical conditions by the same person in the fall of 1917. They were cured in a room where the temperature was about 80° F., being kept covered with sacks which were thoroughly wet daily. Stone and sand were taken from stock piles. Cement was the same in all cases being a standard brand passing standard tests with a good margin.

The beams were broken at the ages specified below, over the same support by loading with paving brick, which were so stacked as to prevent arching action. The result of the tests follow:

Beams 6 in. wide, depth of 1:3½ and 1:3:6 = 5 in.
Depth of 1:4 = 6 in.
Distance between supports, 4 ft. 10 in.
Distance between loads, 1 ft.
Loads equal and spaced equidistant from center.

Beam.	Mixture.	Age. Days.	Extreme fiber stress. Lb. per sq. in.
1	1:3½	34	182
2	1:4	34	152
3	1:3:6 rock	34	188
4	1:3½	60	212
5	1:4	60	180
6	1:3:6	60	190
7	1:3½	90	220
8	1:4	90	178
9	1:3:6 broke in handling.		

A very noticeable difference was the character of the fracture. In each case of the sand mixture the break was clean and sharp, while the rock mixture shelled badly. Several individual pieces of rock were so thickly coated with dust, that there was practically no adhesion of the mortar matrix. This is to be expected, that part of the ledge in the quarry having a coefficient in the neighborhood of 2.

No tests were made of crushing strength because that is not the governing factor in any failure of paving base which has been observed. Failures have been practically always from unequal settlement of old fills or over open spaces caused by settlement of ditches or undermining by leaky water mains. In all of these the beam action of the base has been called into play.

Other failures have been that of cracking under tension caused by soil shrinkage under conditions of extreme drouth. With these tests and local conditions of materials available, together with the desire to insure continuity of supply the following clause was added to the specifications for concrete base:

> The concrete base may be mixed with sand and cement or a mixture of gravel and cement instead of the mixture of sand, cement and stone, under the following conditions: Little River sand free from loam, clay or other impurities, or coarse sand from other sources of which approximately 5 per cent is retained on a ¼ in. mesh sieve and not over 6 per cent passes a 50 mesh sieve and whose voids do not exceed 30 per cent may be used in making concrete, using 1 part cement to 3½ parts sand, volume measurement.
>
> The percentage of cement may be reduced for sand containing more than 10 per cent of particles retained on a ¼ in. mesh sieve in such proportion that the ratio of cement to the sand which passes a ¼ in. sieve is not less than 1 part cement to 3 parts sand.
>
> Well graded gravel, 95 per cent of which is retained on a ¼ in. screen and which is of good hard sound material may be substituted for rock and used under the same proportions for rock and used under the same proportions as provided for rock concrete.

As a result, the sand mixture has been used in all of the paving construction. 400,000 yd. of pavement have been contracted this year and practically all of the base will be laid by the close of the season. Had it been deemed necessary to use rock it would not have been possible to lay more than half of this amount because of the car situation and uncertainties of labor to deliver and handle the stone as it should be delivered. In support of this statement, it might be well to state that a contract was let for the construction of a concrete highway in May of this year amounting to 75,000 sq. yd. Stone requiring a haul of about 250 miles was purchased for the work. Approximately 10,000 sq. yd. will be completed this season. Not all the delay was caused by lack of stone, or even cars to ship it in. The construction of a plant to handle the stone consumed considerable time. The lack of labor at critical times has consumed more.

As to the quality of the base, made with 1:3:5 cement and sand: a great many cuts have been made in various places and in every case it has been tougher and harder to cut and break than base made with the chalky limestone, available within a reasonable distance. One place in particular was observed in which a new sewer ditch was inadvertently covered before being flushed. The base was broken through within two weeks to remedy this defect and was found to be carrying heavily loaded trucks from adjacent flour mills without support for 6 ft. in width and about 40 ft. in length of the ditch. It required repeated heavy blows of a 16 lb. sledge to break small pieces along the edge of the base after it was opened. The impact produced a ringing sound similar to that of striking flinty stone.

These observations together with the behavior of crossings and gutter, made of the same material, under traffic led to the construction of a block of concrete pavement in the fall of 1918. This was mixed 1 part cement to 3 parts sand, laid 6 in. thick and finished with roller and belt.

Cross expansion joints of creosoted wood were placed 30 ft. apart and precast asphalt joints ½-in. thick placed against each gutter. This pavement was laid on a street 36 ft. wide between gutters with a construction joint down the center. A three months' period this season, in which less than 2 in. of rain fell, produced such enormous soil shrinkage that a longitudinal crack has appeared near each quarter of the street for about two-thirds of its length. Otherwise the pavement is in perfect condition and has been the means of bringing in petitions for 75,000 sq. yd. more during the present season.

The mixture was specified as follows:

> The mixture shall consist of 1 part cement to 3 parts clean, sharp sand which contains not less than 5 per cent of material retained on a ¼ in. mesh screen. Sand which contains more than 16 per cent of material retained on a ¼ in. mesh screen may be mixed with cement in such proportions that the sand passing a ¼ in. mesh screen will be 2½ times the amount of cement used. The total amount of gravel retained on the screen shall not exceed the amount passing it in the mixture of the two.

Contracts have been awarded at $1.90 to $2.00 per square yard exclusive of excavation.

In construction it was discovered that if the mixture was made as dry as is now commonly specified, it was impossible to prevent deep shrinkage cracks from developing within a few minutes after depositing the mixture. During the extreme dry weather the subgrade was flooded thoroughly just ahead of the concrete and checking was only stopped by using all the water the mixture would carry without separating and then spraying water over it within fifteen minutes from the time it was laid. This liberal use of water prevented all checking except the usual setting shrinkage cracks which occur transversely about every 30 ft. from a week to 10 days after the concrete is laid.

Another very practical difficulty was that of getting the charging skip of the mixers to scour. One manufacturer sent representatives who made certain changes in the throat which were quite successful.

The general use of sand and cement is not recommended without serious consideration of the character of sand available; its grading, sharpness, freedom from impurities, percentage of voids and material of which it is composed.

How to Get Maximum Efficiency from Construction Labor.— There is no better way of saving labor and getting maximum efficiency out of the labor available than by either the contract or the bonus system, states Mr. Richard Hopkins in a paper presented at the recent convention of the American Road Builders' Association. The reason for this is very simple. A man will work hard and intelligently when it is to his direct interest to do so. Good camps, with a little touch of the human side in their management, will bring both profit and satisfaction to their owners.

The Municipal Contractor and Inconsistent Specification Clauses*

By WM. C. FRASER,
Engineer and Contractor, St. Paul, Minn.

Plans and Specifications and Estimates of Costs.—In preparing specifications the engineer should prepare them from actual measurements and surveys and know that the quantities given are correct; that the plans and specifications and estimates show everything that will be needed to complete the work. If this cannot be ascertained the specifications should so state and contain a cost plus percentage clause allowing extras for unforeseen material and labor needed. The engineer should not expect the contractor to bid on the quantities given and shown on the plans and then guess at what additional work he may see fit to require before he accepts the contract.

The engineer should not expect the contractor to comprehend what will be needed when he does not know himself. The proper way to cover the unforeseen is to have it classed as extra and paid for at cost plus a percentage for use of tools, superintendence and profit. The engineer should take the time necessary properly to prepare the plans and specifications and see that he is properly paid for doing so, for where he guesses at the quantities of material needed and makes an incomplete survey, he only damages his own reputation and makes trouble for himself as well as the contractor. In the majority of cases the city councils wish to have the best kind of work done and are willing to pay for it and the engineer should see that they secure the best possible workmanship and material, and he is sure to have trouble if he does not so show and state in his plans and specifications.

A large majority of the contractors would rather do first-class work that is not only a monument to the engineer, but that will stand as a recommendation to the contractor. We all know that there are contractors who are only after the money that can be made out of the work and their only object is to get through with the contract, secure their money and let the engineer and city council make the best of it. The engineer should see that contractors of that class are not allowed to secure any more work under their plans and specifications. This would encourage the contractor who is willing to do right by the engineer and in time there would be a better class of contractors bidding on work. It is almost impossible for a good contractor who wishes to do first-class work to compete with the contractor who cares nothing for his future standing and reputation.

In submitting estimates, the engineer should know that they are reasonable and that the work can be done for the amount of his estimate. I have found by experience that in the majority of cases the engineer's estimates have been too low for the work contemplated and when it came to letting the contract they could not do so for the reason that the amount of bonds voted was only about two-thirds of the money needed to do the work required. So the work either had to be dropped altogether or reduced so as to come under the amount of money raised. This usually causes dissatisfaction among the residents and trouble for the city council and a loss of faith in the ability of the engineer, while if the estimates are higher than the bids received the city council and the citizens are pleased and instead of diminishing the work, which creates dissension and a damage to the plant, the work can be completed, or even extended, which might assist in satisfying some of the discontented citizens.

Calls for Bids and Proposal Blanks.—Before bids are asked the engineer should see that the plans are properly prepared, so that the city council know just what they are going to have and how they are going to make payment for the work. Contractors should not be expected to bid on work and put up certified checks and agree to give a bond and sign contracts to do work, until they know the class of payments that are to be received and know that the payments will be made as called for in the contract and specifications. They should not be asked to go to the expense of attending lettings unless the city council know that they let the contract if bids are unsatisfactory.

When asking for bids the contractor should be required to deposit with his bid a certified check as a guarantee that he will enter into a contract if the work is awarded to him and the certified check should be for a lump sum so that he will know before leaving home the amount of check necessary.

The engineer should prepare proposal blanks for the bidders so that all bids will be made on the same basis. The proposal blanks should call for a lump sum bid and also for additions and deductions so that the city may have the right to increase or decrease the amount of the contract. These proposal blanks should be made as short as possible, also the contract, and there is no reason why what is put in the specification should also be repeated in the bidding blank and in the contract. The bidding blank and contract should both refer to the specifications and the specifications should cover everything necessary to be done. One or two pages should be sufficient for the bidding blank or contract, and the specifications on the ordinary job should not cover more than 15 or 20 pages.

Contractors' Bonds and Progress Estimates.—The bond should require sureties satisfactory to the City Council and should not state that it is necessary to furnish a surety bond, for in a good many cases a personal bond can be furnished which will save the city considerable money and would be more desirable than a surety bond. The present rate on bonds is 1½ per cent. In many cases this is only a waste of money as the contractor is personally liable and his own guarantee is sufficient to cover all the work that he has under consideration. Where he is able to secure good and reliable personal bonds he should be allowed to do so. By having the clause in this form the reliable contractor may be able to secure a surety bond if he so wishes at a better rate.

In giving progress estimates, the percentage should be as high as possible and the contractor should receive not less than 85 or 90 per cent of the amount of material furnished and work completed the first of each month, and there is no reason why more than 10 or 15 per cent should be kept back as all contracts in Minnesota must be guaranteed by a bond equal to the amount of the contract and when you have this bond, why should it be necessary to hold back an exorbitant amount on the payment of the work? This only curtails the amount of work the contractor is able to handle, makes it necessary for him to borrow more money on which he has to pay interest and eventually has to come out of the city.

Up until three years ago the author of this paper, in bidding on work, never figured anything in for the cost of his bond, employers or public liability, but the rates have become so high in the past few years, that if a contractor failed to add these three items to his bid he would soon be put out of business. As stated before it costs the contractor must add 1½ per cent on the total contract from 2 to 2½ per cent for public liability and from 4 to 10 per cent for employer's liability, so that you see the contractor must add 1½ per cent on the total contract and not less than 10 to 12 per cent on his pay roll to cover these contingencies alone.

Specification Clauses That Tend to Increase the Bidding Price.—The following are a few clauses frequently found in specifications that make contracting very uncertain and where the same are in the specifications it is necessary for the contractors to add additional price to their bids:

Clause 1—The contract price as above set forth shall be the whole compensation when paid, to first party by second party for the laying and construction of said work as set forth in the said resolutions, plans, profiles, specifications and proposal made by the first party whether or not there be as much or more, or less labor, material, excavation or rock cut or otherwise than is estimated by the city engineer has no bearing on the above contract price and does not affect it.

Clause 2—The contractor assumes all risk of variance in any computation or statement of amounts or quantities necessary to complete the work required by this contract, by whomsoever made, and agrees to furnish all labor and material of every description and fully to complete the said work in accordance with the plans and specifications and to the satisfaction of the Common Council for the price bid.

Clause 3—The plans and specifications are intended as complete, but should anything be omitted accidentally from the specifications, which is necessary to complete the work in accordance with the apparent intention of the engineer, it will be supplied by the contractor at no extra cost to the city.

Clause 4—All work not herein or on the plans specified but which may be fairly implied or understood as included in this contract and any apparatus or appliances essential to the proper and convenient operation of the plant shall be supplied and installed without extra charge by the contractor and the engineer or his authorized agent shall be the judge of this.

Clause 5—Any discrepancies in the plans and specifications shall be decided by using the best class of work or material which any interpretation would admit.

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*Paper presented at the annual convention of the Minnesota Surveyors and Engineers' Society.

Clause 6—No claim for extra work or material shall be made or will be allowed except where ordered in writing and all such claims shall be presented monthly in writing within 15 days after the completion of said work.

Clause 7—Should any disagreement arise as to the true meaning of the drawings and specifications in any part, the decision of the engineer shall be final and conclusive.

From advice I have received from attorneys a contractor has the right to bid on the least quantities stated in the contract and specifications and contractors are entitled to rescind a contract with the municipality for the construction of contract work where the contract was made under a mutual mistake, according to the Massachusetts Supreme Court decision. "The estimates on which the contractors made their bid, made by an engineer employed by the municipality and given to the contractors by it as correct, materially underestimated the amount of work to be done, and it was held that the contractor was not bound by them, notwithstanding the estimates were given in good faith, their inaccuracy unknown until after the contractors had begun work, and notwithstanding the contractors expressly covenanted to do the work 'in strict accordance with the maps, drawings, profiles, and specifications prepared therefor, all of which were to be considered as part of the contract and to be construed therewith,' and 'that the amounts and quantities of materials and work as stated in the notice to bidders, governing the making of proposals, were approximate only.'"

Clause 8—No work will be allowed to be laid in water and all work must be kept free from water until cement is set.

Clause 9—The contractor shall, at his own expense, pump or otherwise remove, any water which may exist in the trenches and shall form all dams or other work necessary to keep excavation clean of water during the progress of the work.

Clause 10—In no case shall the sewers be used as drains for water, and the end of the sewer pipe shall be kept properly plugged during construction.

In place of the above would it not be better to state that where water is encountered it will be allowed to drain off through the sewers as they are being constructed under the direction and approval of the engineer, and that upon completion of the work the contractor must see that all sewers are clean and in good order? I have known of cases where it would be impossible to construct sewers unless the water was allowed to run through the sewers as laid. In general, if the contractor undertakes to pump the water out of the sewer ahead of the sewer pipe, he only disturbs the original foundation and is more likely to leave a place where there would be a settlement of the sewer than if the water was allowed to run through and the sewer pipe laid in the trench without disturbing the foundation.

Clause 11—Although the engineer may specify certain methods for constructing work in difficult cases, this will not relieve the contractor of the responsibility.

If the engineer instructs the contractor how to do work and the specifications require that he follow the direction of the engineer, why should this not relieve the contractor of the responsibility?

Clause 12—Where the material at the grade line appears not suitable for securing a firm and unyielding bearing, in the opinion of the engineer, the contractor shall excavate to such depth as he may be ordered to do below the pipe line, and replace the excavated material with sand, gravel, timber or concrete; timber or concrete if used will be paid for extra.

Why should the contractor not be paid for the sand or gravel as well as timber or concrete if used? I have had cases where I have been required to furnish sand and gravel under this clause for which I did not receive pay, while the proper thing to use was concrete but it would have been necessary for them to pay me for the use of concrete and they required me to use the gravel.

Clause 14—Through marshy ground the excavation shall be carried at least 1 ft. below the grade line and lower if required in the opinion of the engineer and filled with sand and gravel.

If this is done, why should not the contractor be allowed an extra as it is an unforeseen item?

Clause 15—No bill will be allowed for material left over on account of any of the above quantities being reduced during the progress of the work, nor will any extra be allowed for on account of any increase in above quantities.

If a contractor is required to sign a contract for a certain quantity of material and the material is left over, why should not the city be allowed to pay for this material, or on the other hand, if after a contractor has been awarded a contract and has ordered his material and the city makes additions and extensions, why should the contractor not receive an amount sufficient to make up for any additional costs in securing this material?

Clause 16—Where pipes are being laid the contractor shall leave uncovered from 20 to 50 ft. of pipe so that the engineer may be able to inspect and test the grades and lines before any backfilling is permissible.

I have found from experience that it is advisable to fill immediately over the pipe before the cement has set. I have been called on to inspect several jobs where there has been a lot of pipe cracked or broken after the construction of the sewers, and the reason for this was that the pipes were laid and left uncovered until the cement had set in the joints which made one continuous line of pipe and allowed no play in the joints, so that when they proceeded to fill the trench after the cement had set there was no chance for any give in the line of the sewer as the backfilling was being put in place.

Clause 17—The successful bidder must sign the contract for the work to be done by him within ten days after the contract is awarded to him, and must begin work at any time fixed by the engineer for him to begin after ten days from the execution of the contract. He shall proceed with the work, prosecuting it with due diligence at such time and in such places with such force as the engineer may direct during the progress of the work and he must complete the work at or before the time fixed for its completion. Should the work under this agreement not be finished within the time specified, the contractor shall forfeit the sum of $25 per day for each and every day that shall elapse after the date fixed for completion. .

You can see that when one or more of the above clauses are put in the specifications it is a difficult matter and practically impossible for a contractor to figure or bid intelligently on the work for it becomes a guess instead of figuring and he can only tell what he is going to have to do when the work is completed and the only way he can come to a basis for a bid is to add a percentage for risks which would be sure to cover the unforeseen obstructions and the engineer cannot expect to get close bids with such specifications and not only that, it bothers the contractor when he comes to secure bonds for the work and makes the bond cost more.

There is generally enough risks to run on this kind of work without putting on additional risks that can as well be covered by percentage clauses. It is also asking considerable of a contractor to sign a contract with a large forfeiture clause in case he is not able to complete the work at a certain date when the quotations he receives on material are headed as follows: "All agreements contingent upon strikes, accidents or other causes beyond our control." Would it not be well to insert this same clause in the specifications and eliminate as far as possible all uncertain clauses in the specifications and prepare them so that the contractor would be able to make a close and intelligent bid on the work and have the uncertain quantity covered by a special clause giving cost plus a reasonable percentage for the use of tools and profits?

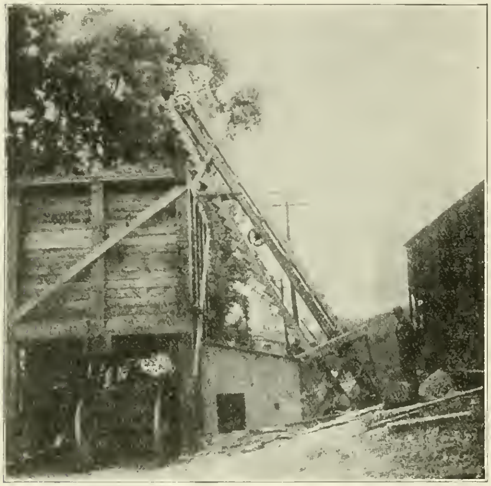
City councils want and should have first class work and material and a contractor should see that he gets a price sufficient to enable him to do his work in the best possible manner and to furnish good material and not slight his work in any particular. He should do work that he can point to with pride and which will act as a recommendation for his ability and honesty. He should not criticize the plans and specifications at the time of the making of bids. If there are objectionable clauses he should refer to them in his proposal and when doing the work should try to get along with the engineer and city council in the most agreeable manner. He should find out, before he bids, if there is anything in the plans and specifications that he does not understand and when he commences the work he should be ready and willing to act in conjunction with the engineer. They should work in harmony to secure the best results and accomplish good work and give to the city the best possible service for the money.

Idaho to Let Contracts for 290 Miles of Highway.—Contracts for Idaho highway projects covering 290.6 miles will be awarded before June, 1920, according to plans made public recently by the state director of highways. During the past year the counties and highway districts have issued bonds for about $12,000,000 for highway improvements.

Cost of Handling Stone from Cars by Slot, Elevator and Bin Method

During the road construction season last year the County of Brant, Ontario, unloaded broken stone from cars and into an elevated bin by the slot, elevator and bin method, at a cost of about 3 ct. per ton. The following information on this method is abstracted from a paper presented last month at the 6th annual conference of Ontario Road Superintendents and Engineers by Alan Mair Jackson, Engineer Brant County:

A slot 4 ft. deep across the track is excavated 16 in. wide between ties and is lined with ties one on top of the other. A plate some 9 ft. long by 16 in. wide is set in this slot at a slope on which stone runs freely, i. e., 30 degrees from the horizontal. The plate should be set so that the largest material will pass under the rail at the upper end and the lower end so that it will discharge on the buckets of an elevator. The elevator is set in a pit at one side of the track with the center of the lower tumbler about 5 ft. below base of rail. With this setting, a 30-ft. elevator standing at 60 degrees from horizontal will have sufficient length to fill a 55-ton bin. The motor consisting, in this case, of a 9 h.p. oil engine is set under the elevator in a small portable house and provided with a clutch drive, by 6 in. belt, onto the jack shaft of the elevator. The elevator is of standard construction 14 in. wide and delivering about 120 buckets per minute.



Car Unloading and Wagon Loading Outfit of Brant County.

The flow of stone to the elevator is controlled by an ordinary slide door operated by a lever and is set between angles fastened to two plates lining the sides of the 16 in. slots at the lower end. The pit in which the elevator is set is made large enough for the operator to get down to the lower tumbler and is timbered on the track side and decked over. A trap door is left in the deck so that the lever operating the stone feed may be got at and cover boards are provided for the slot across the tracks so that the whole may be left safe when not in operation. The usual spacing of ties is about 20 in. centers, which leaves approximately 11 in. space between ties.

Two of these outfits were installed by the County of Brant last year and operated during the construction season. The total kerosene purchased at 20½ ct. for unloading 1,854 tons was 33 gal., giving a cost for fuel of about 4/10 ct. per ton. A 50-ton car can be unloaded in 2½ hours, though allowing for oiling round and starting up, Mr. Jackson figures 3 hours about a fair allowance. The operator in each case has been an unskilled man paid 40 ct. per hour. The bin used discharges through four 12 in. x 12 in. openings in the bottom by means of any one of which a 1½ yd. wagon can be filled in 30 seconds. The height from the ground to bottom of bin is 6 ft. 8 in., though this can be increased by lowering the roadway. The cost of unloading 50 tons may be taken as follows:

3 hours' time at 40 ct.	$1.20
50 tons at 4/10 ct. for fuel	.20
Oil and waste and grease	.10
Total	$1.50

The outfits cost approximately $1,800, made up as follows:

Engine and clutch	$ 545
Elevator	650
Lumber for bin and pit	215
Ironwork for bin and slot	225
Construction	165
Total	$1,800

Mr. Jackson estimates that the unloaders can be taken down and re-erected for about $200.

A bin of this capacity is not portable in the strict sense of the word but the bins used in Brant county last year were made so that the whole structure could be readily taken apart. No nailed parts would have to be torn out except the lining boards of the end of the bin, each of which requires two 4-in. nails, so that no loss should occur in knocking down the bin.

Cost of Loading Snow by Steam Shovel

By JOHN T. CHILD

Assistant Engineer, Rochester Bureau of Municipal Research.

Rochester, N. Y., has joined the cities employing steam shovels for emergency snow work. After snow had accumulated on the ground for over two months a local contractor, Julius Fredericks, put his steam shovel grader into commission and attacked the huge accumulations of snow to prove the value and desirability of a steam shovel for loading heavy snow. The results obtained are summed up as follows:

EQUIPMENT—

Keystone steam shovel with ½-yard skimmer bucket on 18-ft. boom.

SHOVEL COST PER DAY—

Rent, including operator and fireman	$40.00
Coal, ⅓ ton at $8.75, supplied by city	2.25
2 men to release bucket and help move—hired by city	6.08
Total daily cost	$48.33

This cost is equivalent to 16 men at $3.04—the prevailing rate here when the work started. The rate is $3.36 a day now, which would reduce the equivalent to 14 men.

WORKING CONDITIONS—Day shift—8 hours.

Straight work loading from a bank of compact snow 3 ft. or 4 ft. high and 8 ft. to 10 ft. wide. Motor and electric railway—traffic heavy on Main St., East, near Stillson St.

WORK DONE—

Loaded 155 3-yard wagons in 8 hours, or 465 cu. yd.

Cost per load, $0.314.

Cost per yard, $0.104.

Time per load, 480/155 = 3.1 minutes.

Actual loading time—2 min. 6 buckets to a load.

CORRESPONDING LABOR COSTS are $0.107 and $0.12 for hand labor at the two rates.

After the successful try outs with the ½ yd. bucket the contractor purchased a 1 yd. bucket so as to speed up the loading capacity of the shovel. The first few days several moves were necessary and 30 to 40 per cent of the time was lost because there were not enough trucks available to keep the shovel busy. Under these more or less unfavorable conditions as many as 44 9-yd. truck loads were easily handled at a cost of 12.2 ct. per cubic yard.

This shovel was not used early enough in the season to make any prolonged record but it has proven its value under certain conditions and undoubtedly all the available local apparatus of this kind will be listed for emergency snow work next year.

In any event, the steam shovel can be used as a substitute for men at the same cost or less. The larger bucket decreases the actual loading time, and it has several advantages over hand labor. A longer boom will be used next year to reduce the number of moves and give more clearance in loading.

The advantages of the steam shovel for snow loading may be summarized as follows:

1. It can work 3 shifts and better at night in lighter traffic.
2. It could be used to advantage with railway flat cars.
3. It will remove ice and compact snow to the pavement where hand work requires picking and breaking up of the lumps at a greatly increased cost.
4. It can load a higher and hence larger hauling unit.

Reduction of Labor in the Computation of Vertical Curves

By BERRY E. BREVID
Road Designer, District No. 3, Iowa State Highway Commission.

The article by Mr. J. A. Lilly of the Ohio Highway Department, "Instructions and Table for Reducing Labor in Curve Computation," which appeared in the Feb. 4th, 1920, issue of Engineering and Contracting, is of great interest to each and everyone who must design and construct roads. However, when the principles necessary for the calculation of vertical curves is understood the problem is not as difficult as might seem the case at the outset. Mr. Lilly has outlined the work of computing the curves very well, but the writer believes that Mr. Lilly has made the work too lengtby and that the work can easily and quickly be done, with very satisfactory results, by a simple application of the slide-rule.

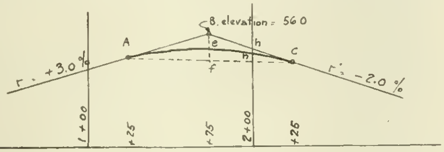


Fig. 1.

Figure 1 is a reproduction of Mr. Lilly's curve with a few additional figures and letters which will be used in the explanation of the slide-rule method.

From Fig. 1 it is evident that the grades r and r', and the position and elevation of B (the P.I. of the two grade lines) are given and it is desired to lay a vertical curve which will be tangent to the two lines at points A and C.

It is first necessary to determine the approximate location of the point "e" (i.e., the position of "e" with respect to the natural ground). Point "f" can now be spotted, making Bf twice as long as Be. A line passing through "f" and intersecting the grade lines equal to distances from B (use two triangles and parallel a line passing through two points, say 50 ft. on either side of B) will locate points A and B approximately after which they can be placed equal distances from B, by calculation, and their elevation computed.

Since the elevation of B and grades r and r' are known the elevations of A and B can be found, and also the elevation of any points "h" for which the grade elevation is desired.

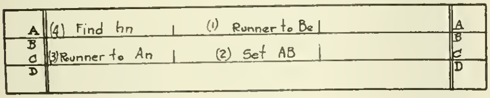


Fig. 2.

It is evident that,

$$\frac{\dfrac{A+C}{2}+B}{2} = \text{elevation of e} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 1$$

For example:

Elev. of A..................................54.5 plus
Elev. of C..................................55.0

Equals 109.5

$$\frac{109.5}{2} = \text{elevation of f} = 54.75 \text{ plus} \ldots\ldots\ldots\ldots\ldots\ldots \text{II}$$

Elev. of B 56.00

equals 110.75

$$\frac{110.75}{2} = \text{elevation of e.}$$

The difference between the elevation of B and E will equal Be or 0.625, Fig. 1...................................III

However, Be can easily be found by a simple slide-rule calculation. As before stated r and r' and tangents AB and BC have been found and with these known quantities the formula

$$\text{Be} = \text{S}\frac{\text{r} - \text{r}'}{4} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{IV}$$

is found, where S is the ratio of the tangent of the curve to 100 ft. For example:

S = 1 when tangent is 100 ft. V
½ when tangent is 50 ft.
2 when tangent is 200 ft., etc.

From the Formula IV:

$$\text{Be} = \frac{\text{r} - \text{r}'}{4}\,\text{S} = \frac{3.0 - (-2.00)}{4}\,½ = .625,$$ which is the same as was found in Formula III.

To calculate "hn's" for any points on the curve, set runner of the slide-rule at Be on the A scale and directly under the runner place the tangent AB on the C scale. To find "hn" move runner to distance An or Cn on the C scale and read "hn" on the A scale.

To calculate elevation of "n" in Fig. 1, set runner at .625 on the A scale and 50 of C scale directly under the runner. Move runner to 25 on the C scale and read .156. See Fig. 2.

The writer having used many methods in the calculation of vertical curves believes that the method as illustrated above is by far the most speedy and is as practically accurate as is necessary. The method is of the greatest value when there are fractional distances encountered at the curves.

Effect of Car Tracks Upon Traffic Capacity of Roadways*

By GEO. W. TILLSON.
Consulting Engineer, La Grange, Ill.

The principal items to be considered are: The location of the tracks, their detailed construction, their degree of perfect maintenance, the character and amount of traffic on the tracks, and the character and amount of traffic on the street or road. The question of location is perhaps the one to be most considered, as upon the location depends the importance of the other items. Its discussion, too, involves the problem of what is the best location for car tracks when they must be laid within the lines of streets or roads. The common practice with streets is to place them in the center, thus giving an opportunity for streams of traffic to move in either direction entirely independent of each other. With this arrangement it can easily be seen that the width between the cars and the curb will have much to do with the effect on traffic.

In the Borough of Brooklyn, New York City, many streets with roadways only 34 ft. wide, have two lines of car tracks and some with a width of only 30 ft. In such cases the obstruction to traffic must be very great as the distance from track to curb is only 9½ and 7½ ft., respectively, and even these distances are reduced by the overhang of the car itself. It is on streets like these that the items of construction, maintenance, amount of traffic, etc., are particularly important.

The writer has always felt that a car track should be so constructed in a pavement that vehicular traffic could pass over it diagonally, squarely or in any direction without any real inconvenience, and that it should be so maintained that it would always meet this requirement. The heavy truck traffic that is so constantly increasing emphasizes this idea. With the present standard rails and latest construction there is no difficulty in meeting what is desired.

Practically all electric roads in streets or highways are operated by overhead trolleys, but in the Borough of Manhattan, New York City, where the underground trolley is used, it is necessary to have a shot half way between the rails of each track. This is also true of cable roads. Such construction makes it very difficult to properly maintain or lay the pavement. The space between the slot and rail is so narrow and so shallow over the conduit that carries the power that ordinary pavement methods are not successful. With the same amount of care in construction and maintenance such tracks are more of an obstruction to traffic than those used with the overhead trolleys.

The writer once saw both in Brussels and also in Vienna an underground trolley system where the slot was built in connection with one of the rails leaving the entire space between the rails unbroken. This seemed much better work from a pavement standpoint, but the engineer in charge of the railways of Vienna said it was not good for operation. Why, this was not explained, but it was thought that possibly it would not permit so good an electrical connection with the car.

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*Abstract of a paper presented at the annual convention of the National Traffic Association.

The Board of Esimate of the city of New York has made a rule that a double track road shall not be laid in a street with a roadway of less than 40 ft. In Philadelphia, where the streets are narrow generally, but on track is laid in a roadway, the cars necessarily having different routes to and from the center of the city.

In some cases where tracks are laid in the center an area is curbed especially for the tracks, vehicular crossings taking place only at cross streets or other especially provided places. This is true in a few other cities, but almost generally so in New Orleans. Here the streets as a rule are wide, allowing plenty of room for this method as well as for the general traffic of the city. In such cases, of course, traffic is not impeded at all except as to general crossing from one side of the street to the other.

Rochester, N. Y., has one or two streets where the tracks are located just inside the curb line. On one of the streets leading out of Paris the writer once saw a similar location. In Rochester the instance noted was on a distinctly residential street, but in France it was in a small retail section.

With such a location the general street traffic would not be effected, but it has always seemed to the writer that it must be very inconvenient to the people along the line, especially if it was on a business street. Here, however, again comes in the question of how much traffic the car line carries and how often the cars run.

Perhaps the best example of obstruction to traffic by car tracks of which the writer has any cognizance is in the Borough of Manhattan, New York City. Central Park West is that portion of 8th Ave. lying directly west of Central Park. This avenue south of 58th St. is 100 ft. wide with a 60-ft. roadway, with car tracks in the center. Central Park West is also 100 ft. wide, but the roadway is only 48 ft. wide and the tracks are laid on the easterly side, the nearest rail being 3 ft. from the curb, leaving a free roadway of 29.9 ft., not taking into account the overhang of the car.

Central Park West is built upon the west side with business houses on its southern end and the remainder with large apartment houses. The cross streets, too, are well built up so that the local traffic is heavy. Previous to the introduction of the automobile the obstruction to travel was not so great. But it can easily be seen that with it being necessary for all pedestrians to cross two lines of vehicular traffic in order to take or leave a car a great deal of trouble must occur.

So many accidents occurred that in 1913 the Board of Estimate and Apportionment passed a resolution directing the railway company to relocate the easterly track at its own expense with the intention of widening the roadway after this was done. It seems, however, that the tracks were located in their present position in 1897 at the request of the park commissioner of the city and the corporation counsel advised that a court seeking to do equity might well deny the application to compel the company to again relocate its tracks entirely at its own expense. The estimated cost of the work was $352,000. Many communications passed between the city and the railway company in regard to the matter, but no physical work was ever done and the tracks and roadway still remain as herein described.

The police reports show that on this street 286 accidents occurred during the years 1910 to 1913 inclusive. In addition to the accidents to persons the police records show that in 1913 there were 36 collisions between vehicles and 8 collisions between vehicles and surface cars. It is also stated that probably only the most serious vehicle collisions are included in the police records. No doubt the number of accidents have increased in subsequent years. In any event, recently Central Park West has been made a one-way street so as to reduce the number of accidents to a minimum. In order to understand just what this means it must be remembered that Central Park extends in width from 5th Ave. to 8th Ave., a distance of ½ mile, and that by making Central Park West a street for southbound traffic only this distance is increased by one long block so that all northbound traffic is cut off between 5th and Columbus (old 9th) Ave. This of course increases the congestion on all north and south avenues. Northbound automobile pleasure traffic, although permitted to go through Central Park, has but two outlets to the west, so that if not through traffic it must be seriously inconvenienced.

Compare for a moment the situation on 5th Ave, south of 59th St. This street is also 100 ft. wide and prior to 1908 had a roadway of 40 ft., with sidewalk spaces 30 ft. wide, but areas and stoops were allowed to encroach 15 ft. so that the free width of the street was only 70 ft. The Board of Estimate and Apportionment by resolution widened the roadway by setting the curb back 7½ ft. on each side and ordered the encroachments back to within 2½ ft. from the property line, thus giving a roadway 55 ft. in width with sidewalks 20 ft. wide free from obstruction. The old roadway permitted four lines of traffic while the additional 15 ft. in width furnished space for two more, and even this is insufficient for the traffic requirements.

The large cars of the Brooklyn Rapid Transit Co., when passing occupy 18.6 ft. Supposing a double track line were laid in the center of 5th Ave., with the traffic it would certainly have when two cars met there would be left on each side a distance of 18 ft., sufficient only for two lines of travel; in other words, nearly all of the benefits of the widening would be lost.

Prospect Park, Brooklyn, has five sides and on all of the adjacent streets there are street car tracks. With one exception the location is similar to that on Central Park West. But on only one street, Prospect Park West, has it been necessary to establish a one-way traffic. This is because both the local street car, passenger, as well as vehicular traffic, is light. During the summer a large part of passengers carried by the car lines have the park itself as an objective and they of course are benefited by having the tracks adjacent to the curb. The situation as a whole, however, well illustrates the bearing of both kinds of traffic upon the subject under consideration.

In another, but perhaps indirect, way can be shown somewhat how traffic is diverted on street car streets, and that is by its effect upon the pavements. In the Borough of Brooklyn careful records have been kept of the cost of repairs to all pavements for more than 15 years, by individual streets. The cost of repairs to asphalt pavements on streets without car tracks for the years 1914 to 1918 inclusive has averaged 2 ct. per square yard and for streets with car tracks the cost has been 3 4/10 ct. While these figures prove nothing directly they are at least indicative as they give results upon 31,645,000 and 3,884,000 sq. yds. of pavement on streets without and with car tracks, respectively.

The problem of track location on roads is somewhat different from that on streets as the local conditions are so different. Then, too, a country road, even if paved, seldom has its pavement of greater width than will accommodate expected vehicular traffic, so that any interference with existing pavement will be serious. Fortunately, however, there are generally no very serious objections to a side location, the tracks being sufficiently far apart to provide for ample width of the pavement between them. The new National highway bill proposes, where feasible, a 66-ft. width of right of way and a pavement width of not less than 20 ft. This would give ample room for car tracks on both sides of the pavement. Whenever a wider roadway is required or any special local conditions arise each case must be considered on its individual merits.

If the tracks are located in the pavement, whether in a city street or country road, the shape of rail and method of construction become very important. As has been previously stated the mere existence of tracks in a pavement should not interfere with traffic. As a matter of fact they do. The writer some 25 years ago saw a track on 14th St., Borough of Manhattan, laid with two center bearing rails instead of one laid on longitudinal wooden stringers, the rails and tracks being so near and of such construction that traffic in the center of the street was almost entirely cut off. Fortunately, such conditions do not now exist anywhere, but they illustrate the importance of the principle.

No doubt the well-known T-rail of the steam railroads is the most economical type of rail for traffic. It does not, however, permit a smooth junction between the pavement and the rail either between the tracks or outside. This type of rail also is liable to cause ruts alongside the rail if the tracks are much used by vehicles. With the present grooved rail in use in most cities with a practically square edge on the outside and the flat lip on the inside, it is perfectly practicable to construct a track that per se will not interfere with traffic, especially if a 60-ft. rail be used. Specially burned brick or specially cut stone blocks are sometimes used in connection with the T-rail, the groove being really cut out of the blocks. This method often produces good results. On a country road where the tracks are laid outside of the pavement the T-rail can of course be used to advantage.

But whatever the style of construction, it should be designed with the idea of keeping both the track and pavement in good condition. Unfortunately the track area of pavements in American city streets are not generally in good condition. Much improvement, however, has taken place during the last 20 years and most street railway companies realize that it is good policy to keep their plant well maintained. Again, unfortunately, soon after this realization the world war came on, bringing with it financial changes to all, but which seemed to injure street car companies more than almost any corporations, bound as the most of them are by franchise obligations as to permissible fares with costs of labor and materials mounting up with aeroplane-like rapidity.

If then car tracks are to exist in paved streets or roadways they should be so constructed as to present as little interference as possible with the pavement. Perhaps the most important item in construction is the type of rail to be used. The roadbed and foundation, too, must be specially prepared. The rail must not give appreciably under car traffic as it is almost impossible to maintain any pavement against a rail that moves vertically under the passage of cars. The joints, too, are a prolific source of trouble. Many times a hole in a pavement along the track has its origin at a defective joint. The use in the last few years of a 60-ft. rail has helped this situation very much.

Admitting the force of the arguments used herein, it follows that street car tracks do obstruct traffic very materially when in use in streets or roadways. Also that the extent of this obstruction depends upon the amount of existing traffic and location of tracks, being greatest where both tracks and roadway are used to their utmost capacity and the tracks laid in the pavement, and almost nil where traffic is light and the tracks located outside of the pavement proper. Probably no better illustration of the relative traffic capacity of street car and non-street car streets can be given than existing conditions on Jackson Blvd. and either Adams or Madison Sts. in the loop district of Chicago in the rush hours.

In designing then a street or road where provision must be made for street car lines, a study must be made of both street car and vehicular traffic, present and prospective, so that the relative importance of each may be determined. As a general proposition the center of a paved street will be the correct location, but often special conditions may make a different one desirable. In the same way it might be said that on a country road the side location would be most logical, changing somewhat possibly when passing through small towns or villages.

Wherever the location, the type of construction should be good, variations being permitted according to exact location and character and amount of traffic.

As careful provision should be made for the maintenance of the tracks and pavement to be kept in repair by the street car company, if any, as for the roadway pavement itself. The writer knows that this is often difficult, but he thinks that unless the company is operating under a franchise giving it special privileges, good results can be obtained by some arrangement. If a new franchise is to be issued, the car company might be obligated to pay a specified amount with the understanding that the highway authorities would keep the pavement in repair. The maintenance of the tracks and roadbed must be left to the operating company.

The writer feels, therefore, that if these precautions are taken that while some traffic obstruction must exist, it will in this way be reduced to a minimum and the general traveling public benefited as much as possible.

$5,000,000 for Road Work in Hawaii Recommended.—Expenditure of $5,000,000 by the United States Army for military roads on the Island of Oahu has been recommended to the War Department by Maj. Gen. C. G. Morton, commanding the Hawaiian Department.

Cost of Quarrying and Crushing Operations in Eastern Ontario

Interesting data on quarrying and crushing operations for the production of road material in Canadian counties were given by Mr. T. V. Anderson, county road superintendent of Lennox and Addington counties, Ontario, in a paper presented last month at the 6th annual conference of county road superintendents and engineers of Ontario. The matter following is abstracted from his paper:

In selecting a quarry, rock containing earthy seams, shelly bedding and heavy overburden should be avoided. The quarry that makes for greatest output is one with light overburden, rock in regular beds from 4 to 9 in. in depth and an average depth of face of 12 ft.

The first matter to be considered in opening a quarry is the removal of the top earth or overburden, which usually costs from 50 ct. to 80 ct. per cubic yard. For quarrying rock the steam drill and jackhammer are most commonly used. A good drill runner and his assistant will easily average 75 ft. of hole per day of 10 hours and the cost will be approximately 16 ct. per foot on the basis of the following prices:

Wages of drill runner	$3.50
Wages of assistant	3.00
Fuel	3.00
Sharpening steels	.75
Rent of engine	2.00
Depreciation of drill	.65
Oil	.25

In quarrying where the rock is comparatively solid the jackhammer is a very useful tool. Owing to its light weight it can be readily moved from place to place by one man and large sections of rock that have been blown out may be quickly drilled and broken into smaller pieces, but where rock is inclined to be shelly the jackhammer is rather difficult to operate, owing to small pieces of stone dropping in the drill hole and clogging the drill.

A crusher with a jaw opening of 10 x 20 in. set to 2 in. will easily average 95 cu. yd. of crushed stone per day. In operating the crusher it is advisable to employ a man to level the stone in the bin, to see that the teams hauling away the stone are quickly and uniformly loaded and also keep a record of the number of yards and trips each team makes.

When the product of the quarry is principally of uniform size, or what is termed one man stone, the unloading platform or drive way should be of such a height that the bottom of the wagon will be a few inches higher than the crusher opening. With stone of this size two men will have no difficulty in keeping the crusher full. When the product of the quarry is small or principally shovel stuff it is preferable to load it in dump wagons or carts.

A platform with approaches built over the top of the crusher and provided with a trap door, can be used to advantage. The contents of the wagon or cart may be dumped directly over the opening of the crusher. This method saves much time of both teams and men and will save many times its cost of erection.

The daily cost of crushing is about as follows:

	Per day.
Engineer	$4.00
Two feeders	7.00
Fuel	5.00
One bin man	3.00
Oil	.50

or approximately 38 to 40 ct. per cubic yard.

The following is a summary of the cost per cubic yard of stone ready for the road:

	Per cu. yd.
Drilling per cubic yard	$0.33
Explosives	.30
Quarrying, sledging and loading	.42
Hauling to crusher	.15
Crushing	.38
Supervision	.05
Contingencies	.12
Total	$1.75

These prices are for limestone quarries and conditions as they are found in Eastern Ontario.

In placing the holes they should usually be about three-quarters of the depth of the hole from the face extending about the same distance apart across the quarry. After the holes have been charged they should be fired by use of a battery. An ordinary battery will fire up to 30 holes at once. Much more can be accomplished by firing a series of holes simultaneously than individually.

In lime stone quarries it will require from ¾ to 1 lb. of explosive of 50 per cent dynamite per cubic yard of rock. The quantity of explosive to be used depends largely on the depth and length of face of the quarry.

In moving the stone from the quarry to the crusher, where the haul is short, one team will haul to the crusher 45 yd. per day. The cost will run about 15ct. per yd. For quarrying, sledging and loading into wagons the cost will average 42 ct. per yard.

Need of Co-Operation Between Contractors and Engineers in State Highway Work*

By A. R. HIRST,

State Highway Engineer, Wisconsin Highway Commission.

I have signed in Wisconsin this year, two or three contracts for concrete roads at prices too low, which I would much rather have signed at higher prices, because my limited experience of 16 years in dealing with contractors has proved to me that there is nothing in the world more unsatisfactory than trying to get a contractor who is stung to do his work, no matter how honest or how strong he may be. He can't put much enthusiasm into putting more money down a rathole, and you can't blame him; it's hard, not to say impossible, to get from a contractor who is losing money, the kind of job which you expected when you let the work, and it's very unsatisfactory work from the standpoint of the engineer.

Yet when a competent and reliable contractor who has been in the business for several years, who has lived through it (I don't know how some of them do) comes in and puts in a bid that is from 5 to 10 per cent too low and you know it, what are you going to do about it? He has successfully built roads before and if we turn him down he assumes we are discriminating against him, and if we open bids again and let it to another contractor for a fair price, say $2,000, $5,000 or $10,000 more than the first price, there isn't a man in the world who would not believe that we got money from the man with the higher price.

Taking Road Work Out of the Guess Class.—Given a set of conditions, I have men who can and will figure a concrete job more fairly, from the standpoint of a contractor, than will about half of the contractors who bid on our work, because they do know and the contractors don't know. About the only thing that many contractors use in making a bid is pure reason. "So and so bid on that job last year such and such a price, this job is pretty nearly like that one, labor and materials will be a little higher this year, and if he bid $2.42, I will bid $2.48." A good many estimates that have been made by contractors have been made just that way.

Isn't it easy to see why the paths of the past are strewn with the wrecks of men who have gone into the highway game? The paths of the future are going to be just as much strewn unless information as to real costs and real values can be got into the hands of the men who bid, either by the State Highway Departments, or other public bodies controlling the work, or by the contractors themselves.

In my opinion, it is going to be necessary to protect the contractors who know and can perform from the bids of men who do not know and cannot perform. You must, for the good of your own profession, help carry on a campaign of education which will educate. I don't see any other answer to it. I am very frank in saying that I believe that the experience of the war has killed the cost plus idea in America just as dead as a door nail. Theoretically, it is all right, but practically, I doubt whether it is possible to carry out any state highway program that way until the odor of the past few years has drifted away from our shores. Work will be done on a unit basis, and we want it to be a fair unit basis. The only way it can be a fair unit basis is by the contractors' first going very extensively and thoughtfully into the question of the kind of equipment which is going to be satisfactory for a concrete road job, being careful to see that the equipment for the job does not run the equipment cost per mile of road up to $10,000 or $15,000 per mile, because it can't be done that way.

The second thing is to educate the engineers, educate the general public, and educate the men who may be led into the contracting business by getting out a form for estimating which will take in all the items which do come in as a part of true cost.

In the estimating sheet which has been worked up in Wisconsin, and which is still in the formative stage, we have found some errors and we are revising it. That cost sheet contains items that the average contractor never heard of, and yet they are items which go into the work and must inevitably be a part of the cost of the work. If every man who bids on a job could get a reliable list of the items which properly go into the cost of performing that job, many would be discouraged from bidding at all, because they wouldn't even know how to guess at some of the items. When we commence to talk about spending four, five, or six hundred million dollars a year on a project, it has gone far beyond the point where it's a laughing matter or a matter for guess work.

The matter of taking road work out of the "guess" class and putting it as near as may be into the "know" class, is a joint enterprise which we must work out together for the common good. You may dispute this statement. But let us assume a minute that engineers would forget all ideas of cost or proper values in the construction of roads this year, and we would let contracts at very fancy prices. Would contractors, who are in the game and who know the game, benefit in the long run? Next year they would be driven out of business by the swarms of mosquito contractors who would rise up to get the easy money. The only thing to do in order to keep this game straight and clean, is to get it on the basis of fair living profits. I would say, even handsome profits, for the men who can do this business right. It might be established on the basis of good profit for the man who knows how, and not on the basis of a Christmas tree on which will be hung ornaments which any fool can grab for. I am absolutely convinced that we can do nothing worse for the competent contractors in America than to let work at superprofits, because that would create a swarm of new and inexperienced contractors who would drive the reliable man entirely out of business.

Contractors Should Keep Accurate Costs.—I therefore appeal to you gentlemen who are connected with this work in any capacity, to keep costs, know what your cost of unloading is, know what your cost is on every item that enters into your work. It isn't sufficient for the contractor to know at the end of a job that he received $200,000 for work that cost him $250,000, and he lost $50,000; or that he has made $50,000 if it's the other way round. If he doesn't know where the loss or gain was, that experience is of absolutely no value to him. He is in the position of the man who has been slammed on the head with a hatchet and doesn't know who held the hatchet; in bidding on his next job he is just as hopeless and helpless as the man who bids on the job without experience, unless he knows just where that $50,000 went.

Every contractor should install in his work, even if it costs him a considerable amount of money, a bookkeeping system and a man to keep the books, so that he is enabled to know what it costs him to operate every item of his business. Not only that, but the system should give him day by day costs to enable him to correct wrong things immediately. You want to learn to tell other men, other engineers and contractors when you have come up against things that have swamped or nearly swamped you, so that your mistakes need not be repeated on other jobs.

If we have to pay for the same mistakes in equipment and operation not once but a hundred times, not in one state but in every state, this process of education is going to be an extremely costly process. We must get together often and discard the bad and select the good. There isn't a contractor who has devised a method or a piece of machinery who can keep it or its results very long from his state highway departments or from other contractors. Machinery is usually operated out in the open and can be seen and its economy can be guessed, so that if a contractor really develops something good, he can't keep it very long and he might as well be polite about it and pass it on before some body steals it.

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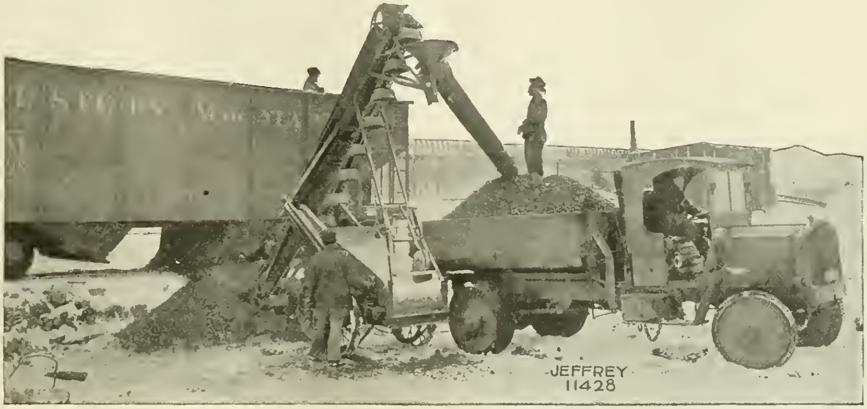
*From an extempore address Feb. 16 before the Highway Division of the National Conference on Construction of the Associated General Contractors.

New Radial Type Loader for Handling Loose Materials

A new design of loading machine, specially adapted for handling crushed stone, gravel, sand, etc., has been brought out by the Jeffrey Manufacturing Co., Columbus, O. The 3-wheel construction of this loader enables it to move backward and forward along straight lines into a pile of material or to cut wide swaths across the face of a pile by swinging alternately upon its driving wheels as pivots, which action is obtained through the use in its driving unit of a set of differential gears, the same as in an automobile, whereby the driving wheels act in conjunction with or independently of each other.



Jeffrey Radial Loader Loading Direct From Hopper Bottom Car Into Motor Truck. An Extra Man Has Been Placed in Car to Feed Material Through the Hopper Doors.

By turning the steering wheel at quite an acute angle to the driving wheels, the discharge chute will remain practically stationary at the center of the circle while the pick-up end of the extending elevator boom will travel in a circular path; or by alternately reversing the propelling drive, the loader will oscillate back and forth in an arc. If the steering wheel is gradually turned through a few degrees either way from the above circular path, the whole machine, while cutting from right to left in an arc, will gradually move forward into the pile, allowing full range of the machine. The loader has a fast speed of 60 ft. per minute for traveling from pile to pile and a slow speed of 4 ft. per minute for feeding into the material. Its capacity is stated to be 1 cu. yd. per minute and it will load crushed stone, maximum size pieces, through 2½-in. ring; maximum size coal, 6-in. lumps. The loader is equipped with either electric motor or gasoline engine. Skilled labor is not required for its operation and all controlling levers are in plain sight and in easy reach of the operator.

Cost of Truck and Team Hauling on a Road Job

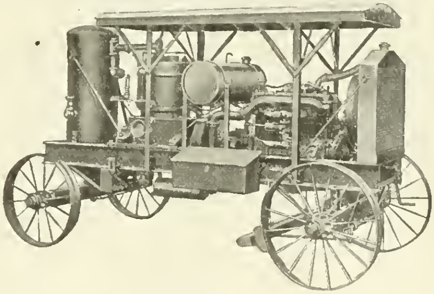
On one of its road jobs last year the County Road Commissioners of Cass County, Michigan, made a test of truck hauling. The results are summarized in the last annual report of D. P. Smith, Engineer of the Commissioners. Three army trucks, received from the State Highway Department, were placed in service on the Wayne Road. The work cards as returned by the drivers showed that the trucks hauled 1,386 yd. of gravel to the road. The total mileage was 9,436 miles. Gasoline used was 2,694 gal. at a cost of $673.50. The oil used was 600 quarts, which cost $60. The total cost for drivers' wages was $832.75. The average haul was about 7 miles. Taking the above figures as a basis the cost per yard mile would be 16.6 ct. for operating expenses while repairs and replacements cost 5.4 ct. per yard mile, giving a total operating and repair expense of 22 ct. per yard mile.

Comparing truck hauling on this same job with team hauling, the latter would cost about as follows: The average distance being 7 miles, a round trip would be 14 miles. As two trips would be out of the question on team this would represent a day's work which could not be obtained for less than $6.50. On a yard mile basis the cost would have to be 62 ct. to enable a team to earn $6.50 per day hauling the above distance. The experience of the Commissioners has been that on hauls of less than one mile the difference in cost between truck and team hauling is not very great. But cheap hauling is not the only advantage of mechanical hauling. Trucks thrive in hot weather and there is no falling off in work on that account. They also know nothing about the 9-hour day and will work as many hours per day as the drivers can stand.

A New Portable Air Compressor for Highway Work

The accompanying illustration shows a new portable compressor outfit made by the Sullivan Machinery Co. of Chicago, which is an entirely new development, based on the company's experience with similar outfits during the past 8 or 10 years. This rig, known as the Class WK-31 Compressor, includes a new, specially designed 2-cylinder, vertical air compressor, driven by a Buda 4-cylinder, 4-cycle, heavy duty tractor gasoline engine, through gear and pinion.

The compressor and engine with the vertical air receiver, the gasoline supply tank, radiator and fan are all mounted on a truck body made up of heavy channel irons, strongly braced. The truck body is mounted on heavy steel wheels, or if desired, the entire rig can be set on a flat-car or other more substantial mounting. The outfit is protected from the weather by a steel canopy top which is provided with canvas curtains. The air compressor has a displacement of 150 cu. ft. of free air per minute, and requires 32 HP. for operation against 100 lb. pressure. The air is admitted and discharged from the cylinder by means of the Sullivan improved wafer valves.



Sullivan WK-31 Portable Air Compressor.

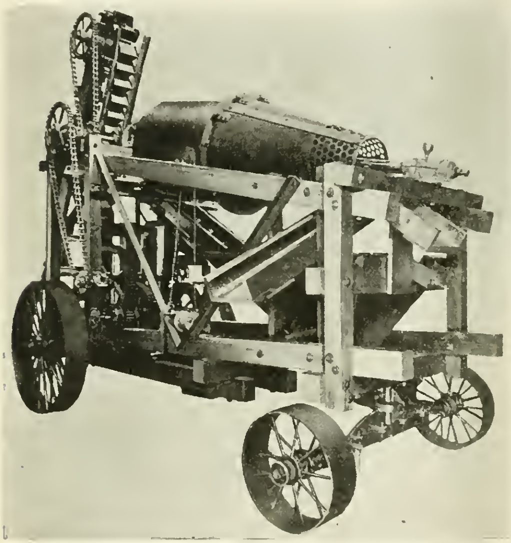
The compressor is cooled by an open hopper jacket into which water can be poured from a bucket or through a hose. Power economy is effected when air is not required by an unloading device and pilot valve, connected with the air receiver which raises the inlet valves from their seats when the demand for air temporarily ceases.

The engine adopted for driving the compressor is of an extremely rugged and reliable type. The engine cylinders are cast en bloc with removable head. The engine is provided with three-point suspension and all mechanism is enclosed and adjustable by means of a movable covering.

The gasoline supply tank will hold 23 gal., which is sufficient for a day's run.

Small Portable Gravel Washing Plant

A small portable gravel washing machine has been developed by the Link-Belt Co., Chicago, not to replace the large permanent plants, but to fill a demand for a small machine which could be moved from bank to bank on road work and contracts where permanent plants are not available and the gravel must be taken from small deposits. The machine consists of an elevator, preliminary scrubber, screen and sand dewatering device—all mounted on heavy wheels with broad tires.



Portable Gravel Washing Plant for Road Work.

The elevator is made with heavy steel buckets mounted on single strand chain. The elevator frame is so constructed that it can be folded up when the machine is to be moved. A small hand winch is provided to handle the elevator when it is to be folded or unfolded.

The scrubber and screen are of the Dull patented type, consisting of a cylinder mounted on the same shaft as the screen and divided into compartments and having lifting vanes or paddles on the inner circumference of the shell. These are so arranged that the material is thoroughly agitated and washed before it enters the screen. The screen is arranged to divide the material into one grade of sand, one grade of gravel and remove the oversize.

The sand and water after passing through the screen drops into a settling tank. The dirty water overflows at the end of the tank and the sand is dewatered by means of a heavy screw conveyor.

The plant is driven by a gasoline engine mounted on the same frame and connected by the necessary gears and drive chain.

The machine washes and screens material thoroughly and is stated to have a normal capacity of about 10 cu. yd. per hour of pit run material.

Personals

David O. Thomas has been reappointed county superintendent of highways of St. Clair County, Illinois.

George A. Campbell, manager of the Reno Power, Light & Water Co., Reno, Nev., and president of the Nevada Highway Association, has been appointed member of the Nevada State Department of Highways.

William H. Bauma of Omaha, Neb., has been appointed county highway commissioner and surveyor of Thayer County, Nebraska.

Capt. S. A. Obershaim has been transferred to Columbia, S. C., where he will have charge of the work of the United States Bureau of Public Roads in South Carolina.

J. Russell Ellis, for three years assistant engineer for the Missouri State Highway Department, has become associated with Winston Lee Winters, civil and hydraulic engineer, Fort Smith, Ark., as principal assistant engineer.

The Westinghouse, Church, Kerr & Co., Inc., engineers and constructors, New York, and Dwight P. Robinson & Co., Inc., constructing and consulting engineers, of New York, have been merged. The new company will be called Dwight P. Robinson & Co., Inc., and will occupy executive offices at 61 Broadway and engineering and designing offices in the Grand Central Palace, 125 East 46th St., New York. Dwight P. Robinson, president of the new company, was for many years president of the Stone & Webster Engineering Corporation, and formed his own company in 1918.

The Dorr Co., Engineers, 101 Park Ave., New York City, has organized a sanitary engineering department, which has charge of all matters relating to domestic sewage and trade waste. Col. I. L. Reeves formerly president of Norwich University, and more recently president of the A. E. F. University of France, has resigned from the army to accept the management of the department. C. Lee Peck, industrial engineer, continues in charge of the research and development work, while R. H. Eagles, also of the Dorr Company staff, will assume charge of the information and extension division.

C. N. Reitze, formerly district engineer of the Seattle office of the Portland Cement Association, has been appointed district manager of the Pacific coast offices of the association at Seattle, Portland, San Francisco and Los Angeles. A. P. Denton, formerly district engineer of the Dallas office of the association, assumes charge of the San Francisco office as district engineer. Charles A. Clark is appointed district engineer of the Dallas office of the association, effective March 15, to succeed A. P. Denton. H. E. French will assume charge of the St. Louis office of the association as district engineer, effective April 1.

H. Eltinge Breed, consulting engineer of 507 Fifth Ave., New York City, has been placed in charge of the courses in highway engineering in the School of Applied Science of New York University. Mr. Breed served several years on road and canal work for the State of New York, was assistant chief engineer of the Coleman du Pont Road in Delaware, and has studied roads and road building in Europe. In 1915 he became first deputy commissioner of the New York State Highway Commission, in which capacity he redesigned the Storm King Highway. He has lectured at Cornell and Michigan Universities as well as at New York University.

Industrial Notes

The Locomotive Crane Co. of America has removed its offices from 36th St. and Ashland Ave., Chicago, to its new plant at Champaign, Ill.

The MacArthur Concrete Pile & Foundation Co. will on May 1 move its offices from 120 Broadway, New York City, to the Anderson building, 12 John St., that city.

The T. L. Smith Co. has established a New York branch office and warehouse service station. The office, which is located at 50 Church St., New York City, is in charge of E. R. Marker, former sales manager, and will supply all the territory east of Cleveland

C. M. Wood, formerly sales engineer for the H. W. Johns-Manville Co., has assumed charge of the recently established Good Roads Bureau of the Goodyear Tire & Rubber Co., of Akron, O., and will devote his entire time to the furtherance of good roads agitation and highway construction throughout the United States.

Charles C. Phelps recently became associated with the Uehling Instrument Co., 71 Broadway, New York, combustion engineers and manufacturers of CO_2 recording equipment and other fuel economy apparatus. He is devoting most of his attention to research work in connection with the efficient combustion of fuel oil in boiler furnaces.

S. K. Miller has been elected vice-president of the Kentucky Wagon Manufacturing Co., Louisville, Ky. Mr. Miller became associated with the company in 1914 in the capacity of assistant sales manager, was made general sales manager in 1918, and at the last annual meeting of the board of directors was promoted to active vice-president. He will retain his place as the head of the sales organization.

The Nebraska State Highway Department has purchased 70 Mammoth graders from the Austin-Western Road Machinery Co. of Chicago. These machines, weighing 6,350 pounds each and having 12-foot blades, will all be delivered in time for the opening of the road construction season. They are being distributed among the majority of Nebraska's 90 counties and are accompanied by heavy tractors.

The Oxweid Acetylene Co., of Newark, N. J., and Chicago, has recently extended its manufacture of oxy-acetylene apparatus and equipmenet to include "Eveready" welding and cutting outfits. "Eveready" is a new name in the oxy-acetylene field, but the apparatus is not new, except for certain refinements of design, having been used extensively in the metal-working trades for several years under the name of "Prest-O-Lite" apparatus.

The Victor L. Phillips Co. of Kansas City, Mo., doing a general business in transportation and construction equipment, has recently purchased the business and good will of Wiley Bros. of Oklahoma City, dealers in contractors' machinery. The business will be continued under the direct supervision of W. R. Wilson, who for the past few years has represented the Victor L. Phillips Co. in Oklahoma territory. Mr. Wilson will be assisted in the business by J. M. Marks and A. F. Luder.

The Barber-Greene Co., Aurora, Ill., manufacturer of self-feeding bucket loaders and standardized belt conveyors, is now represented in St. Louis by R. E. Foulke, 404 Third National Bank Bldg.; Pittsburgh, by J. A. Gurney, 605-606 Arrott Bldg.; Philadelphia, by F. S. Sawyer, 1010 Penn Square Bldg.; Indianapolis, by W. T. MacDonald, 305 Merchants' Bank Bldg.

The general offices of the Chicago Pneumatic Tool Co. have been transferred to the Chicago Pneumatic Bldg., a new 10-story structure erected for the exclusive use of the company at 6 East 44th St., New York. The Chicago district sales branch, previously in the Fisher Bldg., has been moved to new quarters at 300 North Michigan Blvd. The Chicago service branch, formerly at 521 S. Dearborn St., has been consolidated with the sales branch at the new address The Chicago branch is under the direction of J. L. Canby, district manager.

Waterworks and Hydraulics Monthly Issue

ENGINEERING AND CONTRACTING

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The four rotated special monthly issues and 4 quarterly issues of E. & C (52 in all) entirely cover the civil engineering and contracting field at $3.00 a year. Any one of the four special monthly issues may be subscribed for as a monthly at $1.00 a year. The special quarterly issues relate entirely to foreign engineering and construction practice. The *articles* in the first two issues of each month completely cover the municipal engineering and contracting field The *articles* in the first and fourth issues of each month completely cover county engineering and highway engineering and contracting The *articles* in the 3rd and 4th issues of each month completely cover steam and electric railway location, design and construction. See the "masthead" on the first page of the Weekly News Section for information about our weekly contract news

Roads and Streets—1st Wednesday
- (a) Roads
- (b) Streets
- (c) Street Cleaning
- (d) Municipal Miscellanies
- (e) Management and Office System

Waterworks and Hydraulics—2nd Wednesday
- (a) Waterworks
- (b) Sewers and Sanitation
- (c) Irrigation and Drainage
- (d) Power and Pumping
- (e) Management and Office System

Railways and Excavation—3rd Wednesday
- (a) Excavation
- (b) Management and Office System
- (c) Quarries and Pits
- (d) Steam Railways, Construction and Maintenance
- (e) Electric Railway Construction and Maintenance

Buildings and Structures—4th Wednesday
- (a) Buildings
- (b) Bridges
- (c) Harbor Structures
- (d) Miscellaneous Structures
- (e) Properties of Materials
- (f) Management and Office System

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Gompers Does Not Want Contented Workers

The leaders of the American Federation of Labor continue their opposition to "piece work," "profit sharing" and the like. In a letter to Ogden L. Mills, signed by Samuel Gompers, Matthew Woll and Frank Morrison, we read that profit sharing "is calculated to produce docility of spirit and to discourage organizations among the workers. It is a device for the intrenchment of privilege and for the subjection of workers."

It needs no keenness of eye to see the reason for this opposition to profit sharing. "It produces docility of spirit." Yes, profits usually do have some such effect. They make men contented. But contented men are apparently not what Samuel Gompers wants. His job was built on discontent, and he fears that it will end with the end of discontent. Therefore his opposition to profit sharing or any other mode of remuneration in proportion to performance.

Most labor leaders, it should be remembered, are politicians. They secure their positions by election and they hold them by "playing to the gallery." The main object—often their sole object—is to secure an income for themselves. Like the typical politician, they are apt to be born "mud slingers," agitators and soap box orators. Theirs is the "gift" of arousing animosity, and they get their living by that "gift." The evolution of labor unions will eventually bring into power leaders who are more constructive and have real knowledge of the principles of economics. The growing intelligence of the members of labor unions may be counted upon to bring this about.

Healthful Competition Between Engineering Societies

Competition has its profits as well as its losses—a fact that is often overlooked. Socialists harp on the loss string. Individualists harp on the profit string. But some of us harp on both strings.

Competition between engineering societies had not existed to any great extent until the American Association of Engineers came into existence. Whereupon the old national societies sat up and began to take notice of the rival. At first some members were inclined to ridicule the plan of the A. A. E. But neither ridicule nor epithets kill an organization that is fundamentally sound and well managed.

28 Pages=40 pages

The 28 pages of articles in Engineering and Contracting contain as many words as 40 pages of the size and typography commonly used by other engineering periodicals. Ours is the same size of type and type-page as that of The Literary Digest—easily read, yet giving a large volume of reading matter per page. Our 28 pages of articles would fill 112 pages of the standard 6x9 in. text-book. It would take 10 such books of 580 pages each to hold all the articles printed each year in Engineering and Contracting, to say nothing of our weekly construction news.

The next step of some of those who had opposed the A. A. E. was to imitate certain of its major policies. Hence the organization of the Engineering Council. This act on the part of the "founder societies" has been somewhat resented by the A. A. E.; but needlessly so, we are inclined to think. This is an instance where the profits from competition will greatly exceed the losses from it. Let the leaders of the A. A. E. and of the founder societies vie to the limit. There is need here of emulative effort, if ever there was need. Engineers have been too little heard from in public affairs, and too modest in giving publicity to their abilities and accomplishments. All that two great rival organizations will effect in twenty years will scarcely be enough. So here's more power to both of them.

The History of Prices and Wages During and Following Our Civil War

By HALBERT P. GILLETTE, Editor.

In its general effect upon prices and wages, our civil war (1861-5) was similar to the recent world war. This is apparent from the data given last week in my article entitled "Quantitative Analysis of All Factors that Affect Average Prices and a Formula for Predicting Price Changes." But it may be well to supplement the statistics there given with some more that serve to make clearer the parallelism between the economic history of those two wars.

In 1860 and 1861 the per capita currency was about $14 After the civil war was well under way, the currency began to increase rapidly, reaching its maximum in 1865 when it was about $20.60 per capita, or an increase of nearly 50 per cent. Coincidently the weighted average wholesale price of commodities almost doubled, the increase being 90 per cent.

In 1866 the per capita currency decreased to $19, and average commodity prices decreased 16 per cent. In 1867 the per capita currency dropped to $18.30, and remained at about this level till 1874, but commodity prices continued to decline because of the increase in per capita productive efficiency and the decrease in the rate of money turnover, as shown in my article last week.

In 1913 our currency was $34.50 per capita, but in 1919 it reached $54.75 per capita, an increase of nearly 60 per cent. Coincidently average wholesale commodity prices rose 112 per cent. The parallelism with our civil war history will be seen to be very close in respect of currency and price increases.

Table I shows the relative daily wages in 21 industries from 1840 to 1891, taking the average wages in 1860 as a standard of 100 per cent.

It will be seen that wages were nearly 49 per cent higher in 1865 than in 1860. But wages continued to rise for four years after the war ended, until in 1869 they were 67 per cent higher than in 1860, or 13 per cent higher than in 1865. Wages held at this level until in 1873 (or 8 years after the close of the war), when the great panic of '73 caused them to decline. In 1879 wages reached their lowest level, but this level was 39 per cent above the level of 1860. Then wages again resumed their upward march, until in 1891 they were nearly 69 per cent above the level of 1860, and in 1907 were 100 per cent above the level of 1860. Since 1907 no data have been published to show the general average of wages, but it is estimated that daily wages now average fully 65 per cent above the level of 1913, so that we are safe in saying that average daily wages today are 230 per cent above the level of 1860, or 3.3 times what they were in 1860. On the other hand, the buying power of a dollar has decreased to such an extent, that measured in buying power the wages of today are only twice what they were in 1860. For further information on this latter point see my last week's article.

TABLE I RELATIVE DAILY WAGES IN CURRENCY.
(Aldrich Senate Report, No. 1394.)

Year.	Weighted average.	Year.	Weighted average.
1840	82.5	1866	155.6
1841	79.9	1867	164.0
1842	84.1	1868	161.9
1843	83.0	1869	167.4
1844	83.2	1870	167.1
1845	85.7	1871	166.4
1846	89.1	1872	167.1
1847	91.3	1873	166.1
1848	91.6	1874	162.5
1849	90.5	1875	158.0
1850	90.9	1876	151.4
1851	91.1	1877	143.8
1852	91.8	1878	140.9
1853	93.2	1879	139.4
1854	95.8	1880	143.0
1855	97.5	1881	150.7
1856	98.0	1882	152.9
1857	99.2	1883	159.2
1858	97.9	1884	155.1
1859	99.7	1885	155.9
1860	100.0	1886	155.8
1861	100.7	1887	156.6
1862	103.7	1888	157.9
1863	118.8	1889	162.9
1864	134.0	1890	168.2
1865	148.6	1891	168.6

Foot Note:
In 1840 the working day averaged 11.4 hours; in 1860 it averaged [illegible] hours; in 1891 it averaged 10 hours.

TABLE II—RELATIVE PRICES.

Year.	All commodities.	Food.	Clothing.
1860	100	100	100
1865	191	226	259
1869	136	163	130
1874	121	136	112
1879	97	102	85

TABLE III—RELATIVE PRICES.

Year.	All commodities.	Lumber and building materials.	Metals* and implements.
1860	100	100	100
1865	191	182	219
1866	160	187	193
1867	145	179	179
1868	151	174	167
1869	136	166	158
1870	130	148	139
1871	124	151	132
1872	122	167	146
1873	120	172	149
1874	121	155	137
1879	97	115	90

Foot Note.
"All Commodities" is a weighted average wholesale index price of 223 commodities.
The index prices for "Lumber and Building Materials" and for "Metals and Implements" are simple averages.
These index prices are from the Aldrich Senate Report No. 1394.

Average wages continued to rise for four years after the close of our civil war, and did not decline again until after the greatest panic in our history had occurred. The significance of this fact should be plain, namely, that it is futile to postpone construction in the hope of lower wage rates.

Table II gives the weighted average index prices (wholesale) of all commodities contrasted with food and clothing during the period under consideration.

Observe that in 1865, when the average of all commodities was 91 per cent above the 1860 level, the average of food was 126 per cent, and of clothing 159 per cent above the 1860 level. Similarly in 1919 food and clothing had risen far more than the general level of all commodities; for, whereas the average of all commodities had risen 112 per cent above the level of 1913, clothing had risen 170 per cent, farm products 133 per cent, and food 113 per cent.

Based upon the post-bellum price history of 1865 to 1874, we may look for the greatest and most rapid decline in those prices that have risen the most during the war. Clothing rose more in price than any other class of widely used commodity, both in our civil war and in the world war. It will therefore shrink more in price than any other extensively used class of commodity. It is true that there is now a scarcity of clothing in Europe, but during our civil war cotton exports decreased to almost nothing, thus producing a great scarcity of textile goods in Europe. Moreover, it should be remembered that England, France and Germany are in normal times great producers of textile goods, and that it will probably not be long before American markets feel the revival of their textile industries.

During our civil war and the post-bellum years, the relative prices of building materials were as given in Table III.

It is significant that in 1869, when clothing had dropped to 130 (from its 259 "peak" in 1865), lumber and building materials were at a level of 166, or only 9 per cent below their war "peak" of 182 for the year 1865; and in 1873 lumber and building materials were only 6 per cent below the average in 1865.

These facts, taken together with the others that were discussed so fully in my last week's article, are convincing evidence that we shall see little or no recession from the average prices of construction materials for at least five years.

and probably not for ten years. Also it is clear that average wages will continue to rise for several years, and, unless we have a panic comparable with that of 1873 there is no likelihood that that average will decrease for a great many years, if at all.

I showed in my last week's article that we may expect present average prices to fall to a level not lower than about 75 per cent above the level of 1913. I showed that the average prices of construction materials in 1919 were very close to being 75 per cent above the level of 1913.

The history of our civil war as to building material prices has been closely paralleled, and there is every reason to expect that the history of the years following the civil war will be paralleled in so far as the prices of building materials are concerned.

Book Review

Hydraulic Turbines.—By R. L. Daugherty, A. B., M. E., Professor of Mechanical and Hydraulic Engineering, California Institute of Technology; formerly Professor of Hydraulic Engineering, Rensselaer Polytechnic Institute. Third edition, revised, enlarged and reset. Cloth; 6x9 in.; pp. 28; illustrated. McGraw-Hill Book Co., New York City.

The highly specialized subject of hydraulic turbines is presented in this volume in such a thorough manner that anyone interested can find something of use in it. So much new material has been added and so many revisions made, that the original edition is scarcely recognizable. Contrary to most technical books, the theoretical part is deferred until the reader has been familiarized with the general types and principles of hydraulic turbines. The first third of the book is thus devoted to an interesting history of the development of tangential and reaction turbines, turbine governors, and a general discussion of power development. This is followed with a chapter on general theory and a chapter each on the theory of tangential and reaction turbines. A few pages devoted to turbine testing are of interest, particularly the paragraphs relating to the measurement of turbine output and mechanical losses. The author mentions one method of determining output where two or more units are to be tested. One alternator is run so as to drive the other as a synchronous motor. The second rotates the impulse wheel or reaction turbine in the reverse direction. By running varying quantities of water through the latter it is possible to supply any constant load desired.

What constitutes the best practice in turbines is brought out in the latter portion of the book. For any particular power development, the author shows what factors and constants should be determined prior to the selection of a wheel. He then reviews the different types and aims to show just how a turbine can be selected that will fit each particular case. Should the engineer wish more information or wish to design one of his own, two chapters deal with the theoretical design of tangential and reaction wheels.

A chapter on centrifugal pumps has been added to this edition and completes the book with the exception of some appended tables of tests of various wheels.

The text throughout is concise, and the theories are clearly developed and applied to present-day practice. A standard system of notation has been used all the way through. The work is also of special value for college use as at the end of each chapter is a number of practical problems which bear directly on the text.

Cost and Results of Hydrostatic Testing of New Water Mains.—During 1918 eight sections of new mains in the distribution system of Hartford, Conn., were tested at 100 lbs. pressure. The total length tested equaled 7,166 ft., and the average cost of testing was $0.0045. The maximum unit cost was $0.0121 for a section 1.0007 ft. in length and the minimum unit cost was $0.0009 for a section 2,214 ft. long. The results of the tests are summarized as follows by Caleb Mills Saville, Manager and Chief Engineer of the Water Department, in his report for the year ending March 1, 1919:

Size in.	Length ft.	Results.	Leakage per lin ft. of joint gal.	Per 24 hours per inch mile.
6	951	Average	0.13	17
8	3,661	Maximum	0.39	49
10	2,554	Minimum	0.11	13

Land Reclamation in the Mississippi Valley

To the Editor: Your editorial on land reclamation in the issue of March 10 has attracted my attention particularly, and in view of the fact that I have been discussing this question with engineers at various times I feel compelled to make a few remarks in the hope that this important matter will finally receive the attention of some engineers who believe in acting as well as talking.

Is land reclamation in the Mississippi Valley worth while? The engineers with whom I have discussed this problem agree that it is worth while from an economic point of view. They thoroughly believe it is one of those cases in which a certain amount of money can be spent and as a direct result two or three or possibly ten times as large crops can be produced, thereby netting a material profit. And this is usually as far as the matter has gone, as far as the positive side is concerned, for when the matter of financing such work is considered our hands were thrown up in utter despair. The obstacles are like this: Practically all of this unproductive or semi-productive land is privately owned. In reclamation work in the Mississippi Valley either pumping or subdrainage or both is required, and in order to get real results many farms would need to be taken together, because they constitute a drainage district. The owners of these farms can not finance such an engineering feature. Or at least we are in the habit of thinking they can not, and we assume that the government, either state or federal, will not finance it or even help. And yet we know that both these aids have been secured in highway construction.

If I had no faith in this sort of an enterprise I would have been quite unwilling to take the time to answer your editorial. But I do believe that it is an entirely feasible and practical undertaking, and if your readers will go with me for just a moment into the field of logical reasoning and apply modern tactics I think we will be benefited thereby.

Let us visualize this matter from its very inception to its ultimate consummation in an effort to arrive at practical conclusions relative to a program of action. When we do our conclusions will shape themselves in a way similar to the following:

Is reclamation of this nature worth while? (Yes.)

Who will benefit directly? (The farmer.)

Will not those who benefit directly be the boosters for it if they can be persuaded that it will benefit them? (Yes.)

Can they not be persuaded through the moving picture medium?

Once persuaded, will they not proceed to organize into districts whose function it will be to float bond issues and to seek state or federal aid. (And remember when a mass of people wants a thing they get it.)

Finally, it might be well to add that there are existing engineering organizations whose primary function it is to do such professional welfare work as this.

R. E. SPEAR.

Chicago.

The Wages of Union Men and the Salaries of Engineers

To the Editor: I am proud of the way you are allowing your columns to be used by the lay profession in their effort to bring about a better understanding among engineers generally, both in and out of the several societies. I was particularly struck with the directness as well as the array of argument in behalf of the engineer of lesser renown appearing over the signature of J. L. Harrison in your issue of Jan. 7, as well as with a letter somewhat along the same line from C. E. Drayer, Secretary American Association of Engineers, in your issue of Feb. 11.

Mr. Harrison does not underestimate the disparity existing in the fees, salaries or wages as the case may be, of the average engineer and the tradesunion man. In fact, we do not have to resort to the tradesunion in order to find much better paid men—men of far less accomplishment, both mentally and technically. Right here in my own town, where there never has been a local union of any sort (publicly known), we find brick masons, plasterers and cement finishers, most of them of mediocre ability at best and of but a few years' experience, who are actually drawing better pay than inspectors and assistant engineers in our highway departments. To cite a single instance.

In 1915 Jake ——— (colored) worked as second finisher on sidewalk construction for me for a weekly stipulation of $9 and board. Recently I wanted him again for similar work, and although he hasn't done similar work since, and therefore has no added experience, he demanded $45 before he would consent to leave town. Jake is both illiterate and only fairly good at best in his line, but his case is not exceptional and furnishes ground for further consideration among engineers in their welfare work.

As contracted with the aforesaid case, and to still further emphasize the disparity, will say that while I have spent 4 years in college in an effort to learn engineering, and have had nearly 12 years' experience in a general practice—a very satisfactory one for the past 18 months—only recently I received a letter from a division road engineer asking if I would consider $150 a month (without expenses). It can be readily seen, therefore, that engineers themselves are primarily palpable, since they could ask for more, and when they have authority, offer more to their colleagues in practice.

Why should any real engineer work for less that tradesmen?

Lawrence H. McCullough.

Correction

In preparing the illustration, shown as Fig. 6 on page 398 of the article "Quantitative Analysis of All Factors that Affect Prices and a Formula for Predicting Price Changes" in our April 7 issue, a mistake was made in the percentage figures at the left of the drawing. The scale of percentages should have started at 40 and all text references were made on that basis. On page 402 of last week's issue the value of K is given as 1, whereas it should read ½. On page 397, first column and 17th line, the 2.2 per cent should be 22 per cent. The corrected diagram is reprinted herewith.

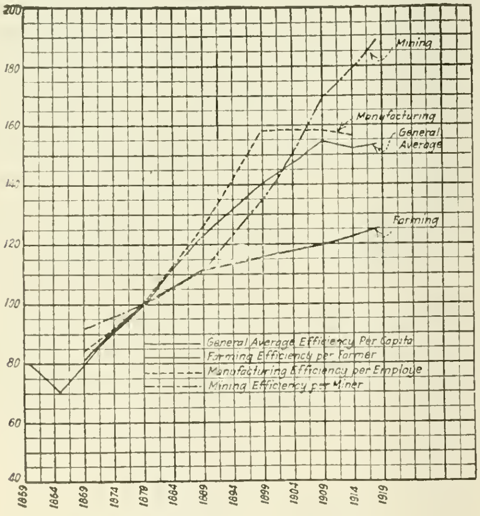


Fig. 6—Productive Efficiency.

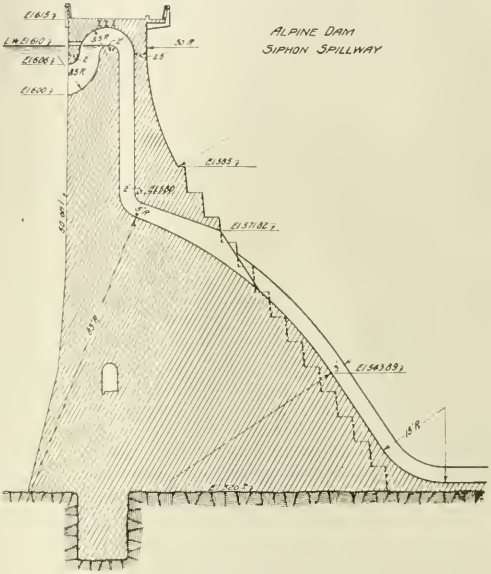
Spring Conference of Engineering Section of National Safety Council.—A number of engineesr who are foremost in accident prevention work and in engineering education are on the program of the first spring meeting of the Engineering Section, National Safety Council, to be held in the Engineering Societies Building in New York City on April 27. The relation between safety and engineering and the engineer's place in the modern industrial world will constitute the motif of the entire program. C. P. Tolman, Chairman, Manufacturing Committee, National Lead Co., and Chairman of the Engineering Section, will preside.

Siphon Spillway of Alpine Dam of Marin Water District

By G. F. STICKNEY

Consulting Engineer, Albany, N. Y.

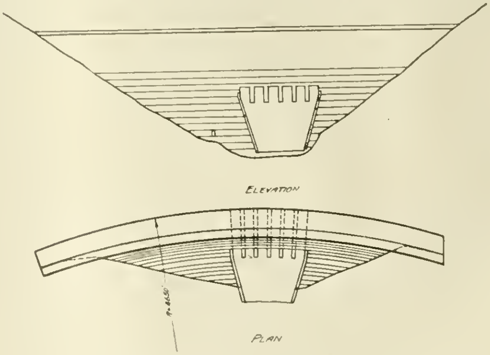
The Alpine dam, in Marin county, California, across the bay from San Francisco, was built to create a storage reservoir in Lagunitas Creek canon, to impound water for the supply of the city of San Rafael and the towns of San Anselmo, Fairfax, San Quentin, Ross, Kentfield and Sausalito, all within the Marin Municipal Water District.



Section of Siphon Spillway Indicating General Design of Units.

A preliminary description of this project was published in Engineering and Contracting, of Dec. 22, 1915.

The dam was completed during the latter part of 1918. It is a concrete structure, of gravity section, curved in plan, 320 ft. long, at the crest, and 100 ft. high, with a roadway on top, carrying the county highway across the canon.



Elevation and Plan of Alpine Dam.

It was deemed advisable to provide a spillway capacity of 1000 cu. ft. per second to take care of the surplus water, and, on account of the steep, rocky sides of the canon at the dam site, this presented something of a problem. An overflow waste weir, of sufficient capacity, must have considerable length and, if placed at the end of the dam, would have necessitated a large waste channel, involving heavy rock excavation.

As a result of the investigations made, it was decided to adopt a siphon spillway, located at about the center of the dam, discharging into the natural channel below, thus avoiding the expense of a waste channel. Other advantages of this type of spillway are that it occupies but a short length of the dam and it limits the fluctuation of the water surface, in the reservoir, to a minimum height above the normal flow line. The spillway consists of six siphons, 3 ft. high by 7.5 ft. wide, each, occupying a dam length of 64 ft., and has a capacity somewhat in excess of 4000 cu. ft. per second.

The siphons are entirely inclosed in the upper part of the dam masonry, as shown by the accompanying section which indicates the general design of the units. The intake, flared out to double the normal section, is located 3 ft. below the throat of the siphon and gradually decreases in area, through the upper leg and throat, to 3 ft. by 7.5 ft., at the top of the lower leg. This latter is vertical, to a point 30 ft. below the throat, where the siphon proper ends.

View of Spillway Showing One of Siphons in Full Operation and Other Units Discharging as Weirs.

Below the siphon, a short bend deflects the flow of water outward to the face of the dam, which, on account of the high velocity of the discharging stream, is formed to a curve of large radius. The discharge is carried down the face of the dam between parapet walls. These walls converge, narrowing the channel to a width of 35 ft. at the bottom of the structure. There are two air vents, 6 in. high by 24 in. wide, in each siphon, which pierce the upstream face of the dam, just above the throat level. The vents vary slightly in elevation, in the several units, and this variation causes the siphons to prime successively, as the water raises, thus adjusting the discharge of the spillway to the outflow required.

The spillway is brought into action by a raise in the water surface, sufficient to submerge the vents, after which priming takes place and the full siphonic flow is very quickly established. A raise of 1 ft., in the reservoir level, will bring all of the siphons into action and they then discharge under a head of 31 ft.

When the reservoir is drawn down so as to uncover the vents, air enters the siphon along with the water and the discharge is somewhat reduced in volume until the vents are uncovered sufficiently to admit a large amount of air, when the siphonic action ceases. The variation in the height of the vents cause the siphons to go out of action, successively, as the water level falls.

The spillway was operated for the first time in February, 1919, when the flow became sufficient to operate three siphons.

The accompanying view of the spillway shows one of the siphons in full operation and the other units discharging as weirs.

The plans for the dam were made by, and the construction was completed, under the direction of Mr. A. R. Baker, engineer of the Martin Municipal Water District, and Mr. M. M. O'Shaughnessy, city engineer of San Francisco, was consulting engineer for the project. The siphon spillway was designed in accordance with sketches, prepared for this work, by the writer.

18 Hints for Machine Trenching

The following useful suggestions for the operation and care of trench excavators were given in a recent issue of Successful Methods:

1. When spudding down the sides, the bank should be broken off a little at a time as close to the buckets as possible.

2. Keep buckets moving when sides cave and hoist boom clear of cave.

3. Trench braces should be placed as close as possible and parallel to boom.

4. When making a turn with a ladder type boom machine care should be taken not to crowd boom against bank. An oscillating type machine will cut on a 25-ft. radius. A ladder type excavator will turn a right angle in about 150 ft.

5. Manholes can be spudded down—machine elevating all material.

6. The boom should be lifted clear of the trench and rested on a support to relieve strain on cables and to protect boom from cave-in.

7. Always put support under boom to safeguard workmen underneath.

8. Large, loose stones should be taken from trench by workmen. Although machine may elevate them, no chances of delaying operations should be taken.

9. When digging down to a ledge of rock, do not try to dig in with bucket teeth.

10. Obstructions, such as sidewalks, pipes, etc., can be undercut by reversing digging traction.

11. Bracing should be of ample strength to preserve the trench and to safeguard the workmen.

12. Trench should be braced where sewer pipe is broken and in places where water is seeping through sides of trench.

13. Keep bucket teeth sharp. In hard digging keep a spare sharpened set on hand.

14. It is essential to the life and proper operation of a machine that all bolts and parts be always tight. Go over entire machine and tighten all bolts once a day.

15. In loading use heavy plank or timbers properly supported. Make runway of sufficient length to keep boom from dragging. Block wheels at all times.

16. Keep machine level so that sides of trench will always be perpendicular. A few boards under the wheels on the low side will do the trick.

17. Keep a record of your machine's performance. Then you will know just how much it earns for you.

18. Watch out for signs that indicate lack of proper lubrication. A little oil at the right time will often save trouble and money.

Bacteriological Tests and Standards in Filter Plant Control*

By MILTON F. STEIN
Civil Engineer, Chicago, Ill.

Limitations and Improvements of Filter Plant Laboratories.—In attempting to fix bacteriological standards for the purity of drinking water and other purposes, the laboratory work on which these were based has been done by expert bacteriologists with aid of the best equipment and all the refinements of the science. On the other hand, the tests, through comparison of which with the standard, the performance of a filter plant is judged, are made in the local filter plant laboratory. I believe it reflects on no one to say that the work of an average filter laboratory is not on a par with that of laboratories maintained by state or national health bodies, if for no other reason, than that the limited amount of work done does not warrant the employment of a first class bacteriologist, nor the time and attention to preparation of media and other details, which can be given when this is done on a considerable scale and with frequency. My limited inspection of laboratories of small filter plants convinces me that before the high standards of purity sometimes proposed can be applied to the filtered water, the laboratories must be standardized; that is, they must be subject to a regular, periodic and detailed inspection by the supervising health authorities, embracing the adequacy and condition of the equipment, bacteriological tests of the media used, and a study and examination of the manipulative methods of the person making the tests. This does not imply that these laboratories are not doing useful work in many instances, but merely that they do not attain the refinement which the proposed standards assume.

Cost of Too Severe Standards in Additional Alum Used.—To show that the standard of purity adopted is of practical importance, I will cite the case of a filter plant averaging 7 mgd., which had given satisfactory service for a number of years, as judged by typhoid records, but in which fermentation tests of the water before chlorination showed more than 20 per cent of the 10 cc. samples positive; this "standard" being presumably based on the rule for common carriers of the Interstate Commerce Commission. The average amount of alum which had been used was 1 grain per gallon. A trial run showed that to keep the positive tests below 20 per cent would require an average of 2 grains per gallon or a half ton additional daily, which at $40 per ton meant an additional expenditure of $6540 per year, an example of the law of diminishing returns as applied to bacterial removal by additional alum.

Bacterial Count and Interpretation.—Suppose we plate three 1 cc. samples of a water. In all probability we will obtain three counts differing from each other, and following the usual, and correct custom we would add these together, divide by three, and call the average obtained the number of bacteria per cc. If we had averaged 10 such counts, we would have obtained a different and more correct result, and with 100, a still more accurate value. The question naturally arises as to how many plates must be made to obtain an average of a certain accuracy, as such knowledge would give us much more confidence in judging the water in question. The figure which gives us this information is called the probable error. For a single plate, the probable error is the square root of the number of colonies present, for the average of a number of plates, add together the number on each plate, take the square root, and divide by the number of plates. Fig. 1 shows the number of colonies, which may be on one plate, or the sum of those on a number of plates, required to give results of a certain accuracy. There are other phases of the probable error, but what has been given is sufficient to serve as a basis for judging the reliability of any set of bacterial tests and will prevent drawing conclusions from insufficient data.

Bacterial Removal or Filter Efficiency on Sliding Scale.—It may be pertinent at this point to say a few words about the bacterial content of filter effluents, based on the 20 degree count, as being the larger and more regular. It is generally known that the percentage of bacteria removed by filtration decreases as the number in the raw water becomes less. While this has been generally accepted, an analysis of the mechanism of filtration discloses no very obvious reason why the percentage removal should not be constant regardless of the number of bacteria in the raw water. It would seem rather that the data on which this conclusion of a decreasing percentage removal were based, were derived from plants filtering turbid surface waters, which were the only waters thought to require filtration in former times, when clarity rather than bacterial content was the criterion of purity.

In such surface waters the number of bacteria increases or decreases as the turbidity increases or decreases. The amount of coagulant added was of course increased as the turbidity became greater, so that the quantity of flocculent, settleable matter composed of the turbidity and the added coagulation was correspondingly increased, entrapping and dragging down the bacteria in the settling basin and forming a very heavy mat on the filters.

It may be said then that filter efficiency is largely controllable by the addition of more coagulant, and if it decreases as the raw water bacteria decreases it is because, for economical and practical reasons, less coagulant is used.

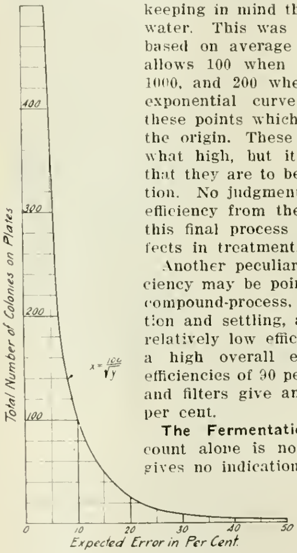


Fig. 1.

It would seem more reasonable to allow the number of bacteria in the filtrate to vary with the number in the raw water, instead of using the single standard of 100 or less, keeping in mind the limitations for potable water. This was done in Fig. 2, which is based on average results in practice, and allows 100 when the raw water contains 1000, and 200 when it contains 50,000, an exponential curve being passed through these points which must also pass through the origin. These values may seem somewhat high, but it should be remembered that they are to be applied before chlorination. No judgment can be passed on plant efficiency from the chlorinated effluent, as this final process would conceal many defects in treatment.

Another peculiarity relative to filter efficiency may be pointed out. Filtration is a compound-process, consisting of coagulation and settling, and of filtering. Thus a relatively low efficiency in each step gives a high overall efficiency. For example, efficiencies of 90 per cent in both the basins and filters give an overall efficiency of 99 per cent.

The Fermentation Test.—The bacterial count alone is not a sufficient test as it gives no indication of the type of bacteria remaining. Long ago it was discovered that the discharges of human beings and warm-blooded animals contained very large numbers of a certain type of bacteria, which when inoculated into sugar broths produced gas. This gave rise to the fermentation test, in which measured quantities of water are inoculated into sugar broths in tubes containing gas traps, and the presence or absence of gas, after incubation noted. If gas is formed, fermenting organisms, presumably of sewage origin, are assumed to be present in the water tested. While apparently giving very direct evidence, there are many uncertainties about this test, and a large amount of work has been done in the attempt to remove these and to establish methods of verification. Often the best verification is obtained through actual observation on the watershed from which the supply is taken. The man in charge of a filter plant should know at what points along the stream sewage enters, its amount, and the strength, in terms of bacteria per cc. Then most of the doubt as to character of fermenting organisms in the raw water vanishes, and any found in the filtered water must have survived from these, assuming the plant in proper condition.

Proper Enumeration of Fermentation Test Results.—Usually no attempt is made to enumerate the fermenting organisms, which we will call b. coli for briefness. This seems a mistake, as this test is complimentary to the bacterial count in fixing the status of a water, and should be expressed in the same units, besides which such expression is more intelligible and aids in forming a correct judgment. Without going into the theory of the matter, it may be said, that by use of a suitable battery of fermentation tubes, ten tubes can be inoculated with little more trouble than one, at least in case of the raw water Then from the proportion of positive tubes, the most probable number of coli per cc. can be read directly from Fig. 3.

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*Abstract of a paper presented March 26 before the Illinois Section of the American Waterworks Association.

Objection has been raised to this method because of the complicated computations involved. However, it can be used by anyone who can count up to ten, and pick a value off of a single line chart, providing, of course that he is willing to take the correctness of the chart on faith.

It would be better to use more tests in determining the proportion positive, but a concession must be made to the limited time available for this work in the average filter plant laboratory. On Fig. 3 a number of other curves are shown, indicating the relation between the number of coli and the proportion of positive tests, when the former vary from test to test in diverse assumed ways. The work of Wolman and Morse has established that in the long run the frequency of bacteria in water follows the normal probability curve. This in conjunction with Fig. 3 leads us to conclude that the basic curve (1) applies not only to a number of tubes made from the same sample at practically the same time, but also very closely to a large number of samples covering a long time period, as a year's daily samples, for instance. For shorter periods of a week, month, etc., the number of coli will generally be higher than the use of the basic curve would lead to believe.

Correlation of Fermentation Tests and Bacterial Count.—Using the method just given for determining the number of coli in the raw water, an additional means for estimating the coli in the filtered water becomes available. From the bacterial count of raw and filtered water the percentage removal can be computed, and this applied to the coli per cc. in the raw water should give the coli per cc. in the filtered water. This is assuming that there are no after-growths in the filters. It forms a useful check on the filtered water, the coli determinations on which are not very exact, owing to the small number present.

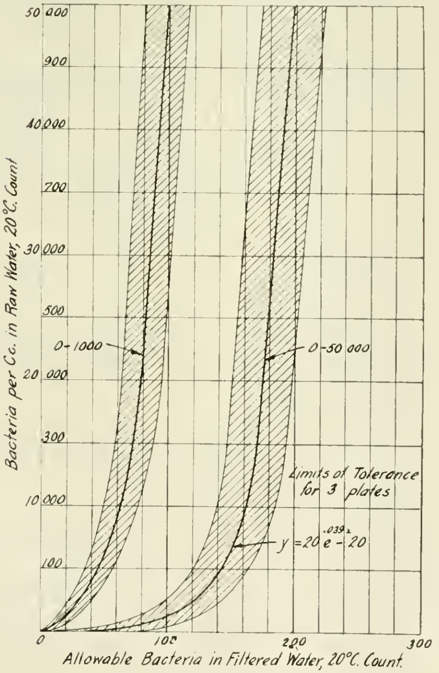


Fig. 2.

Why the Treasury Department Standard Is Not Suitable for Filter Plants.—Various standards of purity have been proposed, but the only one which has come into current use is that of the U. S. Treasury Department for water supplied to the public by common carriers in interstate commerce. It was predicted that this standard would cause some annoyance and trouble to those concerned with municipal supplies when the conditions for which it was formulated were forgotten, and attempts were made to apply it to such supplies.

The essential features of this standard are: that the bacteria per cc. at 37° C. shall not exceed 100; that not more than one of five 10 cc. fermentation tests shall show the presence of b. coli by a partially confirmed test.

The point which should be kept in mind by those tempted to accept this standard for municipal supplies is: that it was devised to determine the safety for drinking purposes, after disinfection, of a small, closed container of water of unknown origin. The reason why a 37° count rather than a 20° count was chosen, was that water bacteria often multiply rapidly when kept in a dark container in a warm room for a considerable time. This is quite evidently different from the conditions existing in a filter plant.

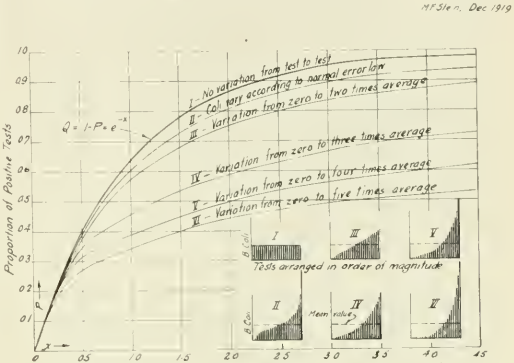


Fig. 3.

As regards the coli tests, let it be remembered first that the water to be tested is of unknown origin, whereas conditions surrounding a municipal supply are fully known. Then that a decision must be reached on a basis of only 5 tests, whereas in a filter plant daily tests, extending years back are often available. Finally, the positive tests are partially confirmed as against the purely presumptive tests usually made in the smaller filter plant.

The Treasury Department report itself states that "the number of samples showing b. coli by presumptive tests may well run to 40 per cent of the 10 cubic centimeter samples." To apply this standard to filtered water, especially before chlorination, seems quite illogical and is apt to needlessly increase the cost of filtration.

One method of attack of the standard problem is to examine the past records of cities taking their supplies from well-protected impounding reservoirs, such as New York. I believe something of this kind was done in the case above, but a liberal factor of safety was applied in addition.

Tracing Chance of Typhoid Infection from Source of Pollution.—Perhaps the most logical method for forming an idea of what various numbers of b. coli per cc. mean in terms of actual dangerous pollution, is to trace the polluting matter from its source to the water supply intake. Great accuracy cannot be expected, as quantitative data are rather meager. There is no reason why this cannot be supplemented, and an analysis along the following lines brought to sufficient exactness to render material assistance in settling the question of permissible number of colon bacilli.

Assume a typhoid death rate of R per 100,000 per annum, and a case rate of 15 R. Assume, further, that all dejecta during the disease are sterilized, and that it is only necessary to deal with the carriers. By various authorities these are placed at about 3 per cent of the case rate. The time for the recovery of a carrier may be placed at 6 months, during which typhoid bacilli are discharged periodically at a decreasing rate, so that we may assume an equivalent period of 3 months at constant rate. By multiplication we can obtain what may be termed a "carrier rate" or number of carriers per 100,000, thus:

$$3/100 \times 3/12 \times 15\ R = 0.1\ R \text{ (approximately).}$$

In the absence of any data, I will assume that in the carriers the b. coli are entirely replaced by typhoid bacilli, which is a very severe assumption.

Actually the discharge of typhoid bacilli in the case of carriers is in periods of short duration separated by much longer periods. But on the assumption made the ratio of typhoid to coli bacilli would be:

$$\frac{0.1\ R}{100{,}000} = \frac{R}{1{,}000{,}000}$$

Thus, in a water containing one colon bacillus per cc. assuming a typhoid death rate of 10, there would be, on the average, one typhoid bacillus in 100,000 cc., or 100 liters of water. This is from 50 to 75 times what the average person drinks per day. It is quite possible that the distribution of the typhoid bacilli is not as uniform as is here assumed, although there is always considerable mixing action in water traveling some distance. On the other hand, it has been shown experimentally that the gastric juices of the normal stomach quickly destroy pathogenic and other non-spore-forming bacteria in reasonable number. It is only when introduced in large numbers, or under special conditions, such as when the acids of the stomach are "bound" by the presence of an excess of proteid foods, that such bacteria reach the intestines, where conditions are favorable for their growth.

I think there is some value in this study in that it tends to show that the task of fixing a line of demarkation between safe and unsafe water is one of great subtlety, and should be exhaustively studied from many angles before a conclusion is reached. Even with one colon bacillus per cc. the polluting matter is only present in extreme dilution, while with two per 100 cc., it would be only one-fiftieth of what this study suggests. Another point brought out is that progress which has been made in diagnosis, disinfection of dejecta, recognition of the part of the fly in the transmission of the disease, etc., have lightened the burden of the filter plant considerably. The mere installation of filter plants in any region lightens their burden, for not only do they remove the dangerous pollution from water passing through them, but to a large extent eliminate the source of that pollution.

Omaha, Neb., Purchases Gas Plant

Omaha, Neb., which on March 20 took over the local gas works, is stated to be the largest city to enter municipal ownership of this type of public utility. The city has a population of about 200,000. The question of municipal ownership of the gas plant has been under consideration since November, 1907, when a special election was called to submit to the public the question of issuing bonds in the amount of $3,500,000. This election was defeated, but again in May, 1918, the proposition of acquiring the gas plant by exercise of eminent domain through condemnation court was carried. The city of Omaha and the company had appraisals made which were submitted to the condemnation court. The Company had three separate appraisals made and the city had the property appraised by Burns & McDonnell, consulting engineers of Kansas City, Mo. The four values placed upon the property were as follows

Burns & McDonnell (representing city)	$3,760,000
W. H. Taylor (representing company)	6,281,000
H. C. Anderson (representing company)	5,518,000
Wm. A. Baehr (representing company)	5,570,000

The above figures represent the depreciated values of the property and include going value. Early in February, 1920, the condemnation court rendered a decision awarding the gas company $4,500,000 as the value of the property, and on March 20, 1920, the city commissioners voted to take over the gas works and its operation at the price of $4,500,000. The city commissioners further voted $1,000,000 as working capital for improvements and extensions.

The appraisal and hearing before the condemnation court has required approximately one year's time, and 13 years after the original proceedings were started the city of Omaha came into possession of the gas plant, and it will be operated by the municipality under a bi-partisan board of directors with a manager in charge of the property. It is anticipated that under the city management the rates will not be increased. The same board that now operates the municipal water plant will operate the gas plant.

Prewar and Present Reproduction Costs of Waterworks

In waterworks appraisals, it is quite necessary to determine what effect the present increased unit costs of all construction materials have on reproduction costs. Prior to the war the most commonly used measure of value was the estimated cost to rebuild or reproduce, using as a basis the costs of a preceding 5-year period. An interesting discussion of the subject is contained in a paper presented by Mr. L. R. Howson, of the office of Alvord & Burdick, hydraulic and sanitary engineers, Chicago, at the last annual meeting of the Illinois section of the American Waterworks Association at Urbana. The following notes are from this paper:

Prior to the war, materials fluctuated in cycles, and a very good idea of the near future prices was possible by a study of the prices of the 5-year period preceding.

Within the last 5 years, however, construction prices and conditions have changed, and the question now arises as to where the reproduction costs of the future will probably lie. On several recent boards of arbitration, selected to fix the value of waterworks properties, two estimated costs of reproduction have been made; one on a prewar basis, and the second on a present day basis of unit prices, and the value reasoned from these limiting estimates.

There are few well-informed people who will contend that prewar prices will ever again prevail in our time. Accordingly, a cost of reproduction, using prewar prices, represents in all probability a minimum measure of the value of the property.

Most appraisers are also of the opinion that the crest of prices has been nearly or quite reached, and that, beginning soon, there will be a slow and gradual recession in prices to some new level intermediate between the prewar and the present. Accordingly, a reproduction estimate made, using the present price basis, represents approximately the maximum value of the property to those who hold this opinion.

The following table shows the comparative reproduction costs of six waterworks based on prewar and present prices:

Plant.	Per cent cost of district system to total pre-war cost.	—Cost of reproduction.—		Excess present over pre-war. Per cent.
		Pre-war.	Present.	
A	58.5	$3,700,000	$6,400,000	73
B	79	280,000	503,000	80
C	61	264,000	444,000	68
D	77	394,000	689,000	75
E	66.5	632,000	1,192,000	89
F	46	761,000	1,242,000	63

With subsequent increases in prices of pipe the figures in the last column would be from 5 to 10 per cent greater. The costs of distribution system materials have increased in relative greater proportion than have other waterworks materials, and, accordingly, the greater the proportion which the distribution system is of the entire property the greater will be the cost of reproduction at present prices as compared to prewar prices.

The data in the above table show that:

1st. For a property in which approximately 50 per cent of the total value prior to the war was in the distribution system, the cost of reproduction at the present time would be approximately 75 per cent above prewar.

2nd. For a property in which approximately 75 per cent of the value was in the distribution system prior to the war, the present cost of reproduction would be approximately double that of the prewar.

There is undoubtedly much difference of opinion as to just where the prices of the next few years will fall; however, there cannot be much disagreement with the statement that they will lie somewhere between the prewar normal and the present prices, and the consensus of opinion seems to be that they will lie closer to the present prices than the prewar prices for a considerable time to come.

Salaries of Graduates of Purdue.—Returns from salary questionnaires sent out by the civil engineering department of Purdue University show that the average Purdue graduate in civil engineering, after he has been out of the university 14 years, receives a salary of $4,500 a year. The average Purdue civil engineer two years out of the university receives $2,000 a year.

Waterworks Data for Small Towns and Villages

By D. D. EWING

Professor of Electric Railway Engineering, Purdue University, LaFayette, Ind.

Public waterworks, because of the indispensability of the service which they render to the communities in which they are located, are very consistent users of power in some form or other. As one interested in the problem of selling power from electric railway and other transmission lines the writer became interested several years ago in the application of electric power to small waterworks plants. Working under the auspices of the Engineering Experiment Station of Purdue University he, with his colleague G. C. Blalock, have made, within the past year, a fairly complete investigation of the problem as far as Indiana waterworks plants are concerned. The results of this work have been summarized in Bulletin No. 3 of the Engineering Experiment Station. The present article deals in the main with an analysis of some waterworks data for two other states, Illinois and Kansas, which are not incorporated in the above mentioned bulletin. The data for the accompanying statistical graphs and empirical equations were drawn from the descriptions of waterworks plants contained in "Municipal Water Supplies of Illinois," by Edward Bartow, Bulletin of the University of Illinois, Water Survey Series No. 5, 1907, and "Water Supplies of Kansas," by C. A. Haskins and C. C. Young, Engineering Bulletin No. 5, University of Kansas, 1915.

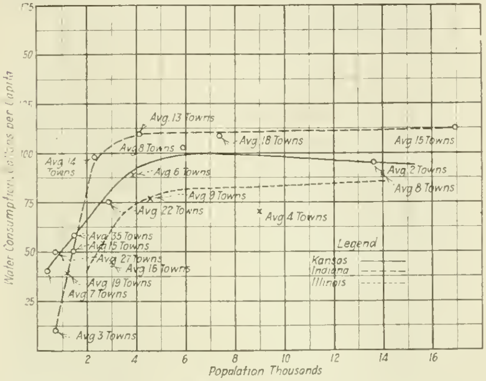


Fig. 1—The Relation Between Water Consumption and Population.

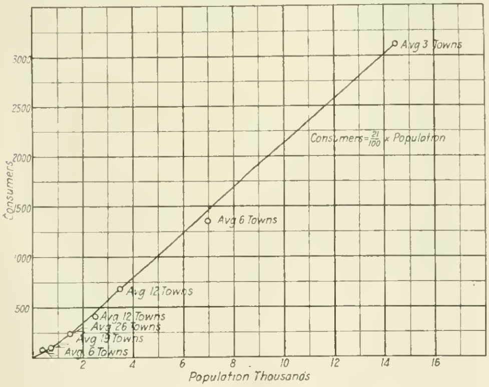


Fig. 2—The Relation Between Number of Consumers and Population.

In Fig. 1 are plotted the relations between water consumption in gallons per capita per day and population for small towns in Indiana, Illinois and Kansas. As is indicated in the figure the points through which the graphs are drawn are averages for a number of communities of about the same size. The water consumption of a town depends on a number of factors, some of the most important being:

Industrial development.
Social characteristics of the people.
Climate.
Character of the water supply.
Sewerage development.
Percentage of metered services.

As the graphs represent average values it is to be expected that in specific cases there may be wide deviation from the figures indicated by the graphs For example, in a small country town of the poorer type with nothing in the way of sewer systems and industries the consumption may be as low as 5 gal. per capita per day. On the other hand in a small city containing a number of fairly large water using industries the consumption may reach 500 gal. per capita per day.

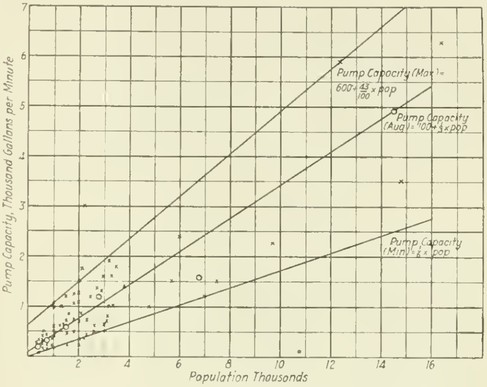


Fig. 3—Pump Capacity and Its Relation to Population.

A study of the graphs indicates that for ordinary middle west towns of less than 4000 population the average daily water consumption may be expressed by

$$\text{Gallons per capita per day} = \frac{\text{Population}}{40}.$$

For towns of more than 4000 population the average consumption is independent of the population and is about 100 gal. per capita per day. In passing it may be stated that reliable water consumption data are very hard to obtain since in only a very few of the plants of the country is the water pumpage metered.

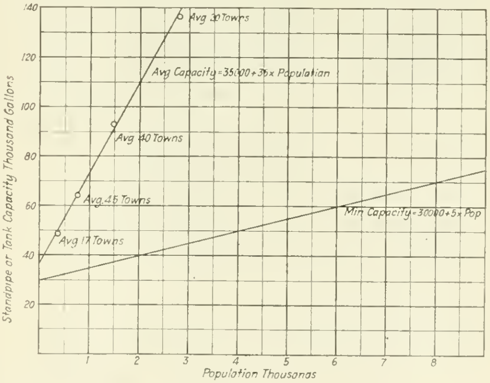


Fig. 4—Standpipe Capacity Required for Various Populations.

The relation between number of cousumers and population for small Kansas communities is shown in Fig. 2. Mathematically the relation is approximately expressed by

$$\text{Number of consumers} = 21 \times \frac{\text{Population}}{100}.$$

or roughly the average number of consumers is one-fifth of the population.

Figure 3 shows the relation between pump capacity in gallons per minute and population and indicates the method used in determining the relation. The figures plotted are for Kansas towns and the equations of the graphs are:

$$\text{Pump capacity (maximum)} = 600 + 43 \times \frac{\text{Population}}{100}.$$

Pump capacity (average) $= 100 + \frac{1}{3} \times$ Population.
Pump capacity (minimum) $= 1/6 \times$ Population.

Similar studies of pump capacity data for Illinois and Indiana plants give the following equations:

Illinois plants:
Pump capacity (maximum) $= \frac{5}{8} \times$ Population.
Pump capacity (average) $= 26/100 \times$ Population.
Pump capacity (minimum) $= \frac{1}{8}$ Population.
Indiana plants
Pump capacity (maximum) $= 11/12 \times$ Population.
Pump capacity (average) $= 43/100 \times$ Population.
Pump capacity (minimum) $= 1/10 \times$ Population.

The constants in the several equations for similar conditions are quite different. It is probable, however, that for ordinary middle west towns the average pump capacity in gallons per minute is about ⅓ of the population. The maximum and minimum equations indicate the range of variation, that is the pump capacity for a town of speicfied population should fall somewhere between the figures given by the maximum and minimum equations respectively.

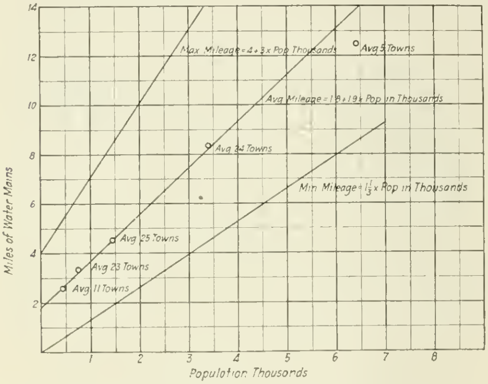


Fig. 5—Mileage of Mains and Population.

Similar graphs showing the relation between standpipe or tank capacity in gallons and the population for small Kansas communities are shown in Fig. 4. The equations of the graphs are:

Capacity (average) $= 35{,}000 + 36 \times$ Population.
Capacity (minimum) $= 30{,}000 + 5 \times$ Population.

For towns under 1500 population a 50,000 gal. tank mounted on a 100-ft. tower is a very common installation. For pneumatic tank systems Kansas data indicates that the

Tank capacity $= 12{,}000 + 5 \times$ Population.

For Indiana communities the data analyzed show that for elevated tanks or standpipes the relations between tank capacity and population are:

Capacity (maximum) $= 50{,}000 + 60 \times$ Population.
Capacity (average) $= 7500 + 37.5 \times$ Population.
Capacity (minimum) $= 15.4 \times$ Population.

A fair figure for the storage capacity needed in an ordinary middle west town is probably given with a fair degree of accuracy by the equation.

Tank capacity $= 25{,}000 + 35 \times$ Population.

The mileage of water mains required for communities of various sizes, as derived from the data for the Kansas plants, is shown in Fig. 5. The equations corresponding to the graphs are:

$$\text{Miles of main (maximum)} = 4 + \frac{3 \times \text{Population}}{1000}.$$

$$\text{Miles of main (average)} = 1.8 + \frac{1.9 \times \text{Population}}{1000}.$$

$$\text{Miles of main (minimum)} = 1\tfrac{1}{8} \times \frac{\text{Population}}{1000}.$$

It is recognized that the design of a new waterworks plant based wholly on the data such as are given above, certainly would not be good engineering practice or even good common sense. In the design or layout of such a plant due weight must always be given to prevailing local conditions. Nevertheless it is believed that such data are of value in making preliminary estimates, in checking tentative designs or layouts and in checking the reasonableness of the operating performance in existing plants.

Operating Results of Water Softening and Purification Works of Columbus, O., in 1919

During 1919 the purification works of the Columbus waterworks softened and filtered 8,299 million gallons of water, an average of 22.7 million gallons per day or 94 gal. per capita per day.

The hardness was reduced from an average of 278 parts per million to an average of 106 parts per million.

To reduce the hardness of water 2,748 tons of soda ash and 5,149 tons of lime were used.

The price paid for the 2,748 tons of soda ash used was $40.50 per ton, whereas the contract price before the war was $13.40 per ton.

The cost of soda ash was	$111,294.00
The cost of lime was	552,571.29

This represents a cost of $448.94 per day for the lime and soda ash treatment alone.

The average turbidity or muddiness of the river water during the year was 71 parts per million, whereas, the turbidity of the filtered water was zero.

The average color present in the above water derived from decay and vegetation was 28 parts per million. By the combined use of lime, soda ash and alum, the color was reduced in the filtered water to 2 parts per million.

The bacterial removal during the year was very satisfactory. The average number of bacteria present in the raw water was 2,300 per cubic centimeter, the median number 400, whereas, the average number present in the filtered water was 25 per cubic centimeter, the median number 7.

Operating expense account of the water softening and purification works was:

Labor and supervision	$ 43,841.58
Chemicals	169,870.07
General supplies	6,600.55
Total operating and maintenance	$219,952.20

The cost of purification per 1,000,000 gal. of water delivered to consumer was $26.50.

During nine months of the year only 9 of the 10 filters were in operation, it being necessary to have at least one filter out of service for repairs. The average daily rate of filtration during the year was 116 million gallons per acre.

The average length of filter runs between washings was 50 hours, and the average per cent washwater was 1.5.

The gravel, covering the strainer system and the sand have become so badly cemented together that the loss of head through the filters is excessive and after a filter is washed, and put in service instead of loss of head starting at zero it has, during the past year, started with an average initial loss of head of 4 ft. The conditions were much worse during the last six months of the year than during the first six months.

The city Board of Health records show that there were only seven deaths from typhoid fever during the year 1919, and that six of the seven deaths were non-residents, leaving only one resident death from typhoid fever. Figuring the population of Columbus at 240,000 would give the city a total death rate of 2.9 per 100,000 population.

The above notes are taken from the report of Charles P. Hoover, Chemist in charge of the purification works, as given in the 49th annual report of the Division of Water of Columbus.

Application of Engineering Principles to Waterworks Operations Offset Increased Costs of Labor and Materials

The water works department of Lynn, Mass., has met increases in wages and cost of materials of 75 to 100 per cent during the last four years wtihout increasing its rates or any increase in the amount of water sold. How this was accomplished is described by Mr. Reeves J. Newsom, Commissioner of Water Supply of Lynn, in a paper read before the March meeting of the New England Water Works Association. An abstract of the paper follows:

The writer took charge of the water supply system in July, 1916, and found an ample field for the application of engineering principles to the methods of operation. The improvements noted are of the kind which will stop wasteage and increase revenue. The improvements needed to better the service will come later.

The Lynn system is supplied by the watersheds of four artificial ponds and the Saugus and Ipswich Rivers. The combined catchment area from which water is drawn covers 58 square miles, and the available yield is about 35,000,000 gal. per day, while the present consumption of the city is approximately 8,500,000 gal. per day. Three pumping stations are used on the supply system to pump water from the rivers, or from one pond to another as it passes through them in the process of purification. A fourth pumping station, located in the city, pumps into the mains and the equalizing reservoir and standpipe. Three of the four ponds are in a chain and have a combined storage capacity of a little under four billion gallons. It requires from four to eight months for water to pass from the rivers into the distribution mains. The fourth pond, with a capacity of 350 million gallons, is used as an emergency supply to the distribution mains and can be filled from two of the other ponds.

The distribution system is about 58 per cent metered and the per capita consumption is slightly over 70 gal. The system is valued at about $5,000,000, with a net bonded indebtedness of approximately $1,000,000. The receipts from the sale of water have varied little from $350,000 per year since 1916, of which from $130,000 to $165,000 yearly has been needed for debt requirements.

One of the first things coming to the writer's notice was the fact that the abatements, including adjustments for advance fixture assessments, amounted to about $13,000 per year. A complete reorganization of very lax office methods, and a strict enforcement of the regulations and the shut-off rule have saved $7,000 per year of this amount.

The service pipe in use by the department in 1916 was a type manufactured with a lining, was of high first cost and when used with Lynn water it did not stand up satisfactorily. After some investigation, it was decided that the most economical and serviceable was cement-lined pipe. To prevent the breakage of the lining with ordinary pipe cutters, all pipe was cut in the shop to fit the requirements by the use of a metal cutting machine, which, on a test with a single blade, cut 140 ⅛-in. discs from a piece of 1 in. lined pipe without breaking the cement. To prevent exposed threads in connections, malleable iron countersunk fittings are used, which we line ourselves with lead, leaving only six threads unlined. When this lining comes in contact with the cement lining of the pipe it makes a snug fit without danger of crushing the latter.

The saving effected by the use of this kind of service pipe is in excess of $4,000 per year.

In 1916 the department depended on the use of horses in all its repair work. The motorizing of this work has reduced the number of foremen from five to four, and the number of men on routine repair work about 20 per cent.

The meter repair shop was not properly equipped to test meters over 1 in. in size and no attempt was made to test and repair meters over 2 in., although 25 per cent of the revenue from metered water was registered by these large meters. A newly equipped testing plant has been built which includes a calibrated tank of 125 cu. ft. capacity. When the city has been entirely covered and all large meters repaired, indications are that revenue in excess of $5.000 per year will be added.

The Glen Lewis pumping station, which lifts water from Walden Pond to Breeds Pond, was equipped with a motor-driven centrifugal pump when it was built in 1912, but it had no meter for measuring the water pumped, and no tests had been made to ascertain the efficiency of the pumping unit. After complete tests had been made, it was discovered that the pump was running at an average overall efficiency of 42 per cent, requiring 90 kw. to pump 14.3 million gallons per day against a 20 ft. head. At a cost of $10,000 this unit has been replaced by a modern centrifugal unit, which delivers 16.4 million gallons against the same head, requires but 60 kw., and operates at 72 per cent overall efficiency. The saving in operation by this substitution is $3,300 per year, or 33 per cent of the investment.

The Walden Pond pumping station which pumped water from Hawkes Pond to Walden Pond was built in 1902 and was in operation in 1916, but has now been abandoned. This was a steam station requiring the usual two men per shift to operate it. The water flowed to the suction well of the pump through an open canal about ¾ mile in length, losing about 20 ft. of head in this operation. The water was then pumped through a 30-in. pipe about ⅓ mile long against a total head of 45 ft. Two men on each shift were required to keep the screens clean in the screen house at the end of the canal leading to the suction well, and to operate the gates controlling the supply of water to the canal, making in all 12 men in 24 hours for the running of the station.

The writer has designed a new station to do this work which is so situated that the total length of 36 in. discharge pipe is 540 ft. and the suction is direct from Hawkes Pond. This station is equipped with a motor-driven centrifugal unit, pumping 20,000,000 gal. per day against a 23-ft. head with an overall efficiency of 74 per cent. This unit is so protected by safety devices that the only attendance required is that given by the regular patrolman on the pond. This change has effected a reduction in labor from 12 men per day to none, a reduction in head pumped against from 45 ft. to 23 ft., a reduction in the cost of pumping from $5.45 to $1.75 per million gallons, and nets a yearly saving of $9,600 in the cost of operation, and required a net investment of but $35,000.

Until recently, the city of Lynn has been compelled to furnish water to the adjoining town of Saugus on the basis that the city should furnish water, make inspections, read meters and collect the water charges. The town was to maintain its distribution system, for which it was refunded 50 per cent of the receipts. Since the city of Lynn furnished all of the water, any wastage in the town system would yield greater returns to the latter.

The proper remedy was to meter the entire town supply, but the determination of an equitable rate was a very difficult proceeding. A thorough investigation including a valuation of the town supply system resulted in a charge of 5.1 ct. per cubic foot for water sold to the town.

In addition to giving up all work included under the old contract, the city of Lynn will receive over $4,000 more annually for this business than formerly.

Elimination of friction losses on the suction of the pumps in the main pumping station will eventually result in a saving of over $6,000 per year.

These improvements have resulted in a saving and added revenue in excess of what would have been obtained by a 12 per cent increase in rates and have enabled the city to meet the necessary advances in prices.

Suggestions for Increasing Efficiency of the Boiler.—Twelve suggestions for increasing boiler efficiency were given in a recent bulletin of the U. S. Bureau of Mines in Boiler and Furnace Testing. The points were:

1. Close up all leaks in the boiler setting.
2. Keep shell and tubes free from soot and scale.
3. Use grates suited to the fuel to be burned.
4. Fire often, and a little at a time.
5. Cover all thin spots and keep fire bed level.
6. Do not allow clinkers to form on side or bridge walls.
7. Keep the ash pit free from ashes and hot clinkers.
8. Do not stir the fire except when necessary.
9. Use damper and not ash-pit doors to control draft.
10. See that steam pipes and valves are tight.
11. Keep blow-off valves tight.
12. Cover steam pipes and the tops of boilers.

The High Cost of Financing Public Utilities

The cost of money to public utilities has not failed to increase with the rising cost of other commodities, and yet, the average citizen can not fail to notice that the cost of water, gas, electricity, and street car service has not advanced in the same proportion.

Mr. D. R. Gwinu, president and manager of the Terre Haute Water Works Co., in a paper read by him before the last annual meeting of the Illinois Section of the American Water Works Association at Urbana, Ill., states that in a compilation made by him, he found that since 1914 the average increase in the cost of 29 items entering into the operation of a water works plant was 86.7 per cent. The average increase in the cost of labor at the Terre Haute plant since 1914 is 63 per cent. An abstract of this paper follows:

Cost of operation enters indirectly into the cost of money, for when there is a big increase in cost of operation without an increase in gross earnings, there is a reduction in net earnings which may materially affect the attractiveness of bonds. And if bonds are not attractive to the buyer, he will expect a larger discount, which means a higher cost to the utility for the money he rents.

Where the utility must filter and sterilize water, the cost of operation is subject to an unusual increase. It is necessary to maintain the standard of purity regardless of cost or dividends.

The company whose bonds matured since the United States entered the great war was extremely unfortunate. The author is familiar with the refinancing of a water company whose 4½ per cent 20-year bonds matured last June. There was approximately $1,000,000 outstanding. It was necessary to issue $1,035,000 6 per cent 5-year securities which were sold at 94, or at a discount of 6 per cent. The company is required to pay into a sinking fund out of surplus earnings $20,000 per annum for retiring the securities. The annual interest charge was increased $17,100; that is, from approximately $45,000 to $62,100. The discount when amortized over the 5-year period, amounts to $12,420 per annum, making an increase in the cost of money to the company of $29,520 per annum. However, there were other costs in connection with the issue of the securities, such as attorney fees, traveling expenses, revenue stamps and printing; the fees to the state amounted to $2,087 for authority to issue securities. The company assumed the income tax up to 2 per cent on the bond interest. Outside of these extra costs, which were kept at the minimum, the cost of money to the company is 7.63 per cent. Including the additional expense, the cost is almost 8 per cent.

In five years from the date of issue, the whole program must be repeated. It is to be hoped, however, that the cost of money at the time of maturity will be lower than at present. Fortunately for the company, the Public Service Commission authorized an increase of rates, which has been a great help, although the increase was not as much as was asked for, or what the company thought it was entitled to.

The case referred to is not an unusual one, as public utility securities have been offered recently to yield the investor in the neighborhood of 8 per cent. This would mean that the cost to the utility for money would be considerably more. When a utility must pay 8 per cent and, in some cases, 10 per cent for the use of money, how can it be expected to do business and furnish satisfactory service on a 7 per cent rate of return?

The author has a list of about a dozen large utility concerns, the securities of which were offered to yield from 7.18 to 8 per cent. This will give an idea of the yield to the investor, but it should be borne in mind that the actual cost to the utility is greater than the figures mentioned.

Property that is dedicated to the use of the public should be treated fairly and liberally, otherwise capital will seek other investments. Unless the rate of return is such as to attract capital, the property can not be improved and needed extensions made. The result is that the public suffers. The public is willing to pay reasonable rates for good service. An inadequate rate of return not only hurts the utility, but it hurts the public.

Water companies and water departments have been given some relief, but, in a general way, it would seem that the relief has not been in proportion to the rate of increase in the cost of operation and in the cost of money.

In justice to many commissions, it may be stated that they are making a conscientious effort to give the necessary relief and it is to be hoped that the vision will be broad and clear; that the public service commissioners will realize that if service is to be continued and of proper standard, that liberal treatment in the way of return is absolutely necessary; that, in order to borrow money to make extensions and improvements, it is necessary for the utilities to make a reasonable profit in addition to mere interest; that the public should be protected in the way of securing service as well as in the matter of rates; that the public will not be benefitted by driving private ownership from the utility field; that with money costing 8 to 10 per cent and a rate of return of only 7 per cent, the end will not be long postponed.

High Pressure Fire System of Atlantic City, N. J.

A high pressure fire system in which the supply and pressure are furnished by a group of individuals and the system furnished by the city has recently been completed and tested in Atlantic City, New Jersey. The group of individuals comprise the expensive beach front hotels which maintain high service pumping equipment ready for immediate use in case of fire. This system is described in a paper presented before the March meeting of the New England Water Works Association by L. Van Gilder, Engineer and Superintendent of the Atlantic City Water Department. The following notes are abstracted from the paper:

Class G, Am. W. W. Assn. Standard C. I. pipe is used to withstand a working pressure of 300 lb. All line joints are of the New York type, poured with pure lead. Hydrant branches were caulked with an alloy of 95 per cent lead and 5 per cent lead, and were tested to 400 lb. without bracing or backfilling, with no leakage.

Hydrants are trimmed and bolted with bronze to prevent salt water corrosion. The hydrant valves have pilot valves to insure easy working under high pressures.

The main line under the Boardwalk is 20 in. diameter and 6,500 ft. long, with two hydrants at each street and one midway. All cross street lines are 12 in., with hydrants spaced about 150 ft. apart.

Pressure for the system is furnished by 8 pumps which have a maximum capacity of 11,000 gal. per minute at 150 lb. pressure, and are located in the largest hotels, principally along the beach front.

A domestic pressure of 40 lb. is maintained at all times, and, at a recent test, the pressure was raised in 1½ minutes Fire alarms are maintained in all engine rooms with 24-hour service. The operation of the fire pumps takes precedence over all other equipment in the hotel if necessary.

The cost of the system to date is about $225,000, involving fixed charges for interest and sinking fund of about $13,500, while the reduction in insurance premiums has amounted to fully $40,000.

Annual Convention of A. A. E.—It has been decided that chapter representation at the 6th annual convention of the American Association of Engineers will be in proportion to chapter membership. One chapter is entitled to one delegate or more, not to exceed one for each 100 members. Each delegate is entitled to cast a number of votes equal to the number of certified and junior members in good standing in the chapter which he represents, but not to exceed 500 in all. One of the subjects to be discussed is, "The Reorganization of A. A. E. on a Business Basis." The suggestion has been made by W. W. K. Sparrow, assistant chief engineer of the Milwaukee, that the association employ a high-salaried paid president. On the evening of the first day of the convention, Monday, May 10, there will be held seven group meetings for various groups of engineers. Among the subjects to be considered are: Getting Salary Schedules for Public Service Engineers Into Budgets; What Part Shall A. A. E. Take in the Presidential Campaign?; Making a Chapter a Force in the Community; The Federal Department of A. A. E.; Opportunities for the Engineer in Each of the Various Branches of the Profession; Co-ordinating A. A. E. Activities in the State.

Methods of Detecting Leaks in Underground Pipes

Methods for the detection of leaks in underground water pipes are numerous, but it is seldom that one can find a description of as many of them contained in a single paper as there were in the one presented by H. E. Babbitt, assistant professor, municipal and sanitary engineering, University of Illinois, before the recent annual meeting of the Illinois section of the American Waterworks Association at Urbana, Ill. The following notes review most of the various methods described in this paper:

The simplest method for locating a leak is by observation, but it is not always true that the leak is directly below the point of observation. A sounding rod is useful in many cases. A ½-in. rod about 5 ft. long can be driven down to the pipe in most soils. If the rod on withdrawal is moist, the indications are that the leak is farther up grade, if not, the leak has been passed and lies in the opposite direction. By driving the rod a few times it is often possible to isolate the leak at once. An aquaphone used in connection with the sounding rod locates the leak by finding the place on the pipe where the loudest noise is produced. The aquaphone is an instrument that transmits the sound waves of the water issuing from the leak through a metallic diaphragm to the ear. Other similar instruments make use of electric currents for amplifying the sound waves. In all of these methods, however, direct contact with the pipe is necessary, generally through a rod driven in the ground, or other metallic connections to the mains.

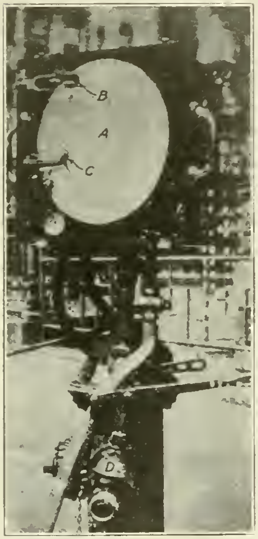


Fig. 1—Pulsograph on Hydrant. A, Recording Dial; B, Time Recording Vibrator; C, Pressure Recorder; D, Quick Opening Valve to Create Water Hammer.

Another form of leak locator is a sound producing instrument that does not require direct contact with the pipe. A very delicate sound detector is set up on a 4-legged brass table which rests on the surface of the ground, and is protected from air currents by placing a box over it. The vibrations set up in the detector are converted to electric waves which are transmitted through an amplifier to a very sensitive telephone receiver. The instrument is so sensitive that it will detect the sound of a leak through the pavement and the ground at the ordinary depths to which water pipes are buried.

The phenomenon of water hammer is useful in locating a leak in a water pipe. It is well known that if a valve in a pipe line is closed quickly a pressure is set up in the pipe. This pressure is called water hammer. It differs from the effect caused by a blow in that the pressure is maintained for some time. A wave of high pressure travels from the valve up the pipe to a point of relief and a wave of low pressure then returns to the starting point at the valve. The pressure at the valve fluctuates above and below normal until the disturbance has become stilled by the friction of its passage through the pipe, and the pressure returns to normal. Intermediate discharges between the valve and the point of relief will cause fluctuations in the pressure at the valve after the water hammer has been created.

The speed at which the wave travels is affected by the diameter of the pipe, its material, and other factors and varies between 3,600 and 4,200 ft. per second. In the application of this phenomenon to the location of a leak, the approximate location of the leak should be determined and the line of pipe on which the leak is located should be isolated by the closing of valves so that it is connected to only one large service main, preferable much larger than the pipe in question.

It may be necessary to shut off service connections or to apply the method at night when the service pipes are not drawing water. A quick shutting valve is attached to a hydrant so located that the leak is between it and the water main. The distance from the hydrant to the connecting main along the pipe line should be measured accurately. A delicate recording pressure gage is attached to another nozzle on the hydrant. The dial of this gage is evolved by clock work. Time is recorded by the vibrations of a tuning fork.

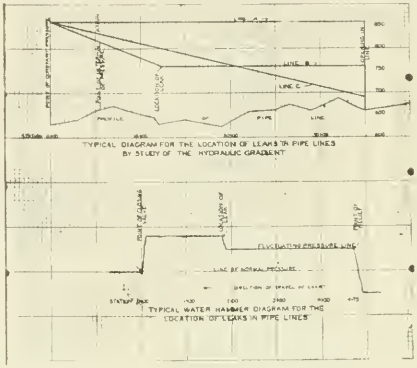

POINT OF CONSTANT PRESSURE
LINE B
LINE C
LOCATION OF LEAK
OPENING IN LINE
PROFILE OF PIPE LINE
850
800
750
700
650
600
TYPICAL DIAGRAM FOR THE LOCATION OF LEAKS IN PIPE LINES BY STUDY OF THE HYDRAULIC GRADIENT
POINT OF CLOSING VALVE
LOCATION OF LEAK
POINT OF RELIEF
FLUCTUATING PRESSURE LINE
LINE OF NORMAL PRESSURE
DIRECTION OF TRAVEL OF CHART
TYPICAL WATER HAMMER DIAGRAM FOR THE LOCATION OF LEAKS IN PIPE LINES

Fig. 2—Diagram for Use in Determining Leaks in Pipe Line.

After the instruments are connected, the valve is opened and water allowed to flow from the hydrant. The valve is then closed suddenly. On the closing of the valve, the pressure line on the diagram will jump up. The pressure will remain at this height until a slightly relieving wave has returned from the point of the leak when it will drop a little The pressure will then remain constant until the low pressure wave has returned from the point of relief. The exact location of the leak is then determined by proportional distances from the diagram (Fig. 2.)

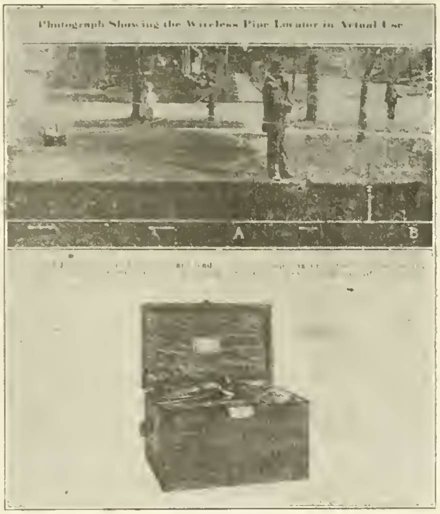


Fig. 3—Wireless Pipe Locator in Actual Use.

(A and B) The Service Pipe—Iron or Lead—Also Stop Box or Cutoff Covered by the Grass; (C) The Mains in the Street; (X) The Field. The Arrows Show the Direction of the Current.

The characteristics of the hydraulic gradient are useful in the location of a leak. The upper diagram in Fig. 2 represents the profile of a long pipe line or a portion of a distribution system. It is suspected that a leak exists somewhere between station 0 + 00 and 35 + 00. If the pipe line is shut off completely except at 0 + 00 and no leak exists, the hydraulic gradient will lie along the line A and the pressure throughout the pipe line will indicate this height. If the pipe is opened and no leak exists the hydraulic gradient will be represented by the line C provided the diameter and other conditions are similar throughout the line. If a leak exists and the pipe is closed, the pressure at station 35 + 00 will be less than that a 0 + 00. The gradient will slope uniformily downwards from 0 + 00 to the point of the leak and then run horizontal to station 35 + 00 as shown by line. The position of the gradient, represented by the two straight lines can be determined by locating any two points on each line. The leak will be found at the intersection of these lines as shown on the Fig. 2. This method was used with success by the writer in locating a leak in a 5-mile pipe line at Nogent-en-Bassigny, France, during the war.

A method requiring the use of chemicals was suggested by T. J. Hoxie in the Journal of the New England Waterworks association, Vol. 27, page 307. The leak is located tentatively within a certain section of pipe which is then isolated as in the preceding method. It is essential that all service connections be closed. A corporation cock is tapped into the main somewhere above the leak. To this is connected a 6 or 8-in. length of 2 or 3-in. pipe and a valve. Two or three pounds of caustic sofa are inserted in the tube, the large valve closed, and the time of opening of the corporation cock noted. Samples are collected at various points along the line and tested for alkalinity with phenolphthalein. As soon as the alkalinity is found at any one point it indicates that there is a leak beyond that point because the flow created by the leak has carried the chemical down. Finally a point will be reached where the alkalinity does not appear. The indication is that the leak is somewhere between this point and the point at which it was last found. Water is withdrawn at the point at which the alkalinity has not appeared and the quantity withdrawn before the alkalinity does appear is carefully measured. This quantity, divided by the volume per unit length of the pipe will give the distance to the leak. Any number of leaks can be detected in this fashion.

An ingenious method based on volumetric displacement was used for the location of a leak in a pipe line in Chicago. A piston was made which fitted the inside of the pipe. A Y-branch was inserted in the pipe line and the piston was put in the pipe through this branch. A cable attached to the piston was passed through a packed joint in the plug closing the Y-branch. The water was then gently turned in the pipe just sufficiently to keep the piston moving. When it had reached the leak it stopped, and the length of the cable measured the distance to the leak.

A simple method for the location of a leak in a submerged pipe is to dump a quantity of bluing in the line. The appearance of the bluing in the river or harbor will locate the position of the leak. Other equally difficult methods may be as effective as the more scientific methods just described.

If the location of the pipe line itself is unknown there is an instrument available known as the wireless pipe locator by which the exact location of the pipe can be determined. The apparatus, shown in Fig. 3, is manufactured by the Clark Co., of Mattoon, Ill. An electric circuit is made by connecting two points on the pipe line by an electric wire. A battery and vibrator are put in this circuit, the vibrator serving to interrupt the current rapidly. An induction coil and a detecting coil connected to a telephone receiver are carried in the hand. When the induction coil held in a horizontal position is brought into the vibrating electric field set up by the electric circuit through the pipe and wire a singing noise is heard in the telephone receiver. The volume of sound increases until directly over the pipe when it ceases altogether. If the coil is then turned in a vertical position the loudest sound is heard.

Contract Let for $1,200,000 Canadian Drainage Project.—The Public Works Department of British Columbia, at Victoria, B. C., has awarded a contract for constructing the Sumas Lake drainage project to Marsh-Bourne Co. The contract price is $1,200,000. The improvement will reclaim several thousand acres of land.

Copper Sulphate Treatment to Counteract Algae Growths in Large Reservoirs

The minute plant growths that develop from time to time in waters that are exposed to the light represent a troublesome problem to the waterworks operator. The use of copper sulphate to destroy such growths is well recognized in the water supply art, but its application has been limited to comparatively small bodies of water, such as distribution reservoirs and relatively small collection and storage reservoirs, or else to the shallower areas of large reservoirs. The problem of destroying such growths in reservoirs holding many billions of gallons of water is one which it is believed has not been previously solved, and about which there are few or no data available. The description by Mr. Wm. W. Brush in the March Journal of the American Waterworks Association of some recent experiments in this line, undertaken in connection with the Catskill water supply of the city of New York is therefore of particular interest and is accordingly reprinted below.

During the two years that the Catskill system has been utilized to supply about three-fifths of the total water consumed in the city of New York, there has been anxiety over the possibility of microscopic algae growths simultaneously appearing in both the Ashokan and the Kensico reservoirs in sufficient numbers to noticeably and disagreeably affect the taste and odor of the water delivered to the consumer. Up to December, 1919, there had peen no such simultaneous growth, although an uncomfortably narrow margin of time had separated in the past the dying out of a growth in one reservoir and the development of a growth in the other reservoir. Before the Catskill supply had been introduced, an unsuccessful experiment had been tried in the Croton aqueduct, by treating the waters from Croton lake with a solution of copper sulphate, to determine whether such treatment would destroy these growths, and it therefore appeared doubtful whether copper sulphate treatment could effectively be applied to water flowing through a long aqueduct.

In December conditions developed in the Catskill supply which made it necessary to do whatever seemed to offer even a remote chance of success in killing the algae growth. In the Kensico reservoir asterionella had developed in all parts of the reservoir to an extent of over 2000 units per cubic centimeter. In the Ashokan reservoir the growth of asterionella had reached in both basins an equal or greater number of units. This number of asterionella is sufficient to cause a disagreeable geranium taste and odor, which is most noticeable in the hot water. At this time ice was forming in the Kensico reservoir, and it was decided to treat that reservoir as quickly as possible with as much copper sulphate as could be gotten into solution.

The reservoir has an irregular shape, and there is a distance of about 3 miles between the point where the flow from Ashokan enters the reservoir and the point where the water is drawn out to be delivered to the city. The reservoir at this time was substantially full, and held above the aqueduct level about 29,000,000,000 gal. It was estimated that if 6,000 lb. of copper sulphate were used it would be possible to treat with a strength of about one part to five million in weight the waters in that portion of the reservoir which lay between the influx chamber and the efflux chamber, extending to a line approximately half way between the side of the reservoir on which both the influx and efflux chambers are located and the opposite side of the reservoir. This work was immediately undertaken but the rapid formation of ice stopped the work when approximately 5000 lb. of copper sulphate had been added. To prevent further seeding of the reservoir with algae growth, and to still further reduce if possible the growth already in the reservoir, it was decided to experiment with treating the flow in the aqueduct by continuously introducing copper sulphate in the proportion of one part to five million by weight, the chemical to be introduced at the alum treatment plant, which is located about an hour's flow upstream from the influx chamber at the Kensico reservoir. A mechanical feeding device installed at this alum plant permitted a very close regulation of the rate of feed of the copper sulphate. The treatment was started, using about 625 lb. per 24 hours, the flow through the aqueduct being uniformly maintained at very close to 380,000,000 gal. daily. This treatment has now been continued for three weeks, and the results obtained are interesting, although not considered conclusive as yet.

The treatment of the water in the reservoir resulted in an irregular change in the number of units that appeared in the supply as drawn from the reservoir. This supply is passed through the aerator, and the sample taken after the water had passed through the aerator and through Hillview reservoir, which contains about three days' supply, showed that the organism had lost its virility, many of the units appearing to be mere shells, and almost no complaint has been registered on account of taste and odor from the organism, although frequently there have been as many as 2,000 to 3,000 units per cubic centimeter. The treatment of the flow through the aqueduct shows very little change in the number of organisms at the point where the water is discharged into the reservoir, but samples taken at points ½ mile apart and extending 2 miles down the reservoir, indicated that the growth has been substantially eliminated through this treatment. The appearance of the organism as it enters the reservoir also tends to corroborate the conclusion that the treatment has been effective.

In samples taken during the week ending Jan. 17, 1920, the number of organisms at the point where water enters the reservoir was 1,350; at point ½ mile below the intake, 1,400; 1 mile, 115; 1½ miles, 1,925; 2 miles, 1,825. These figures indicate that the treatment of the inflow to the reservoir has been felt for a distance of a mile from the influx chamber, this being about the distance that flow from the aqueduct could be expected to extend during the three weeks' period of treatment.

The cost of this treatment is about $50 a day and is a negligible amount when it is divided by the number of million gallons treated, as the resultant cost per 1,000,000 gal. is about 13 ct.

Sewage Disposal and Physical Chemistry

Editorial in Chemical and Metallurgical Engineering.

Some of us who have arrived at years which we hold to be those of discretion, but which are not generally considered to indicate the peak of man's productivity, are likely to grow a little testy about physical chemistry. This is especially the case if we have been lazy in our reading, or if we have let our mathematics and physics drift into those cloudy regions of memory where we keep our Latin grammar and our Greek verbs. We are apt to forget the available fields of research which should precede the methods of trial and error. We wonder if this has not been the case in regard to sewage disposal.

We have considered oxidation in many aspects, chlorination of effluents, the SO_2 reaction and a few other indefinite chemical phenomena, and thereupon we have addressed ourselves to the engineering problems. So we wonder if we have not begun with engineering a little too soon. If there is anything that the conscientious engineer needs to know, no matter of what particular kind he may be, it is the nature of his materials. Now, sewage and its disposal is largely a problem in colloid chemistry, and it may be that the subject has not been adequately studied from the colloid point of view. The chemical behavior of solid substances is largely dependent upon the surface of their particles, and this in turn is determined by the size of them. In such a miscellaneous mess as sewage we have presented a vast field for colloidal study, and the treatment is bound to be chemical if we would change its nature so as to rid it of offensiveness.

It may be that talent and scholarship of the first order in physical chemistry have been addressed to this subject, but if this be true the fact has escaped us. What we should like to see would be a comprehensive study undertaken of the physical chemistry of sewage in a laboratory where modern physicochemical methods of research prevail. It would give the engineers a better show—a better opportunity to design apparatus to meet existing conditions. It may be possible to coagulate sludge and to separate it from the effluent in a much more effective manner than we now know. With an improved method of separation established it might open the road to a real solution of this perplexing problem. The record of chemistry in regard to sewage is not complete. The case is not closed. Our rivers are still canals of filth, while they carry off to the sea a wealth of nitrogenous material of which we are still in such need that we are at our wits' end to produce it.

Comparative Costs of Lead and Cement Joints for Cast Iron Gas Pipes

In a paper presented before the Pacific Coast Gas Association, Mr. W. M. Henderson gave some interesting data on the cost of making lead and cement joints for the cast iron pipe distribution system of a gas company. The table following is abstracted from his paper:

MATERIALS AND COST OF MAKING LEAD JOINTS.
(Per Joint.)

4-In. Pipe—	
Lead, 10 lb.	$0.77
Yarn, .33 lb.	.042
Time, 12 min.	.140
Total cost	$0.95
6-In. Pipe—	
Lead, 12 lb.	$0.92
Yarn, .5 lb.	.06
Time, 12 min.	.14
Total	$1.12
8-In. Pipe—	
Lead, 18 lb.	$1.39
Yarn, .55 lb.	.07
Time, 15 min.	.17
Total cost	$1.63
10-In. Pipe—	
Lead, 20 lb.	$1.54
Yarn, .8 lb.	.10
Time, 20 min.	.23
Total cost	$1.87
12-In. Pipe—	
Lead, 24 lb.	$1.85
Yarn, .8 lb.	.10
Time, 24 min.	.27
Total cost	$2.22
16-In. Pipe—	
Lead, 32 lb.	$2.46
Yarn, 1.2 lb.	.15
Time, 30 min.	.69
Total cost	$3.30
20-In. Pipe—	
Lead, 42 lb.	$3.23
Yarn, 1.66 lb.	.21
Time, 30 min.	.69
Total cost	$4.13
24-In. Pipe—	
Lead, 50 lb.	$3.85
Yarn, 2 lb.	.25
Time, 40 min.	.92
Total cost	$5.02
30-In. Pipe—	
Lead, 70 lb.	$5.39
Yarn, 2.75 lb.	.35
Time, 60 min.	1.37
Total cost	$7.11

MATERIALS AND COST OF MAKING CEMENT JOINTS.
(Per Joint.)

4-In. Pipe—	
Cement, 3 lb.	$0.02
Yarn, .25 lb.	.03
Sand, 2 lb.	.02
Time, 15 min.	.17
Total cost	$0.25
6-In. Pipe—	
Cement, 5 lb.	$0.04
Yarn, .33 lb.	.04
Sand, 3.3 lb.	.04
Time, 15 min.	.17
Total cost	$0.29
8-In. Pipe—	
Cement, 6 lb.	$0.05
Yarn, .5 lb.	.06
Sand, 4 lb.	.05
Time, 20 min.	.23
Total cost	$0.39
10-In. Pipe—	
Cement, 8 lb.	$0.07
Yarn, .66 lb.	.08
Sand, 5.3 lb.	.07
Time, 24 min.	.28
Total cost	$0.50
12-In. Pipe—	
Cement, 10 lb.	$0.09
Yarn, .75 lb.	.10
Sand, 6.7 lb.	.08
Time, 30 min.	.34
Total cost	$0.61
16-In. Pipe—	
Cement, 12 lb.	$0.11
Yarn, 1 lb.	.13
Sand, 8 lb.	.10
Time, 30 min.	.69
Total cost	$1.03
20-In. Pipe—	
Cement, 15 lb.	$0.13
Yarn, 1.25 lb.	.16
Sand, 10 lb.	.13
Time, 40 min.	.92
Total cost	$1.34
24-In. Pipe—	
Cement, 23 lb.	$0.21
Yarn, 1.75 lb.	.22
Sand, 15 lb.	.19
Time, 60 min.	1.37
Total cost	$2.00
30-In. Pipe—	
Cement, 30 lb.	$0.27
Yarn, 2 lb.	.25
Sand, 20 lb.	.25
Time, 80 min.	1.83
Total cost	$2.61

The methods employed in making the cement joints were described by Mr. Henderson as follows:

The practice which is more or less general of using neat cement for packing the joint is not proper, and will not give the satisfaction obtained from a mixture of portland cement and sand. Neat portland cement, in setting, rises in temperature over a range of 60° F. to 150° F., or not in excess to 10° F. in 12 hours. This is considerable expansion during setting of neat cement, which will likewise be followed by contraction. This fact accounts for the shrinkage cracks.

Quick setting cement is preferable, but cements in the market give little choice in this respect. Good clean sand, not too fine, and not necessarily sharp, will make a strong mortar. The yarn is also an important factor; the old hemp rope, the standing rigging from sailing vessels, cannot be excelled.

The best mixture for the joint is 3 parts cement to 1 part sand, and just sufficient water to make a dough that will hold its shape. The quantity of cement, sand and water should be mixed as necessary for each joint as it is made.

In laying pipe for cement joints the procedure is very much as with lead, with a few additional precautions. The pipe must be in its permanent resting place well blocked and tamped. As much as possible of its surface should be covered with earth, so as to protect it from change of atmospheric temperatures. One should also avoid stepping on the pipe when getting in and out of the ditch; this should be a hard and fast rule, particularly after cement joints have been made up and are green. The joints are best made in the afternoon, permitted to set through the night and tested the first thing in the morning. If they are found to be tight, the backfilling should be done at once to protect the pipe from the heat of the day. Those joints left exposed during the day must be shielded from the sun's rays, and it is well to cover them with a wet sack as additional protection.

In making the joint the bell is first cleaned by the hand bellows. Then a strip of hemp yarns is placed in the bell and driven home; this should be made tight. The balance of the bell is then filled with the mixture of cement grout; this is usually placed in the joint with the fingers and rammed in by a yarning iron or a wooden tool of similar shape. The cement is packed until it properly fills the bell, then another strip of yarn, coated with mortar, is set in the bottom of the bell and forced into the ring. The balance of the space to the face of the bell is filled with either neat cement or the same mixture and the entire joint is pointed at an angle of 45°.

Operating Results for 10-Year Period of New Orleans Water Purification Plants.—The year 1918 closed the first 10 years of operation of the Carrollton and Algiers water purification plants of New Orleans. The following tables give the maximum, minimum and average results for this 10-year period:

OPERATING RESULTS OF FILTERS.

Carrollton Plant—1909-1918.

	Length of run in hours.	Corresponding net rate of filtration M. G. per A. per 24 hours.	Corresponding quantity of water filt. (gallons).	Corresponding per cent of wash water used.	Corresponding length of run 125 M. G. per 24 hour rate.
Maximum	531.3	96.2	68,100,000	0.1	408.6
Minimum	3.8	71.0	387,000	23.2	23.2
Average	132.7	80.4	13,589,000	0.6	81.5
Algiers Plant—1910-1918.					
Maximum	633.2	425.0	9,100,000	0.2	425.0
Minimum	6.8	78.5	91,600	153	4.3
Average	146.6	97.0	2,362.500	0.6	107.4

GRAINS OF LIME AND IRON PER GAL. USED IN TREATING WATER.

Carrollton Plant—1909-1919.

	Lime.	Iron.
Maximum	10.32	2.96
Minimum	0.85	0.006
Average	4.84	0.50
Algiers Plant—1910-1918.		
Maximum	13.50	6.11
Minimum	0.72	0.01
Average	5.37	0.73

Water Consumption in Cities and Towns of Western Canada.—The accompanying table, compiled from figures in the 1918-19 report of the Reclamation Service branch of the Department of the Interior of Canada, shows the average daily water consumption in imperial gallons in 1918 for 18 cities and towns in Alberta and Saskatchewan:

Alberta.	Population.	Per head for domestic purposes. Imp. gal.	Per head for industrial purposes. Imp. gal.	Per head for other purposes. Imp. gal.	Per head for all purposes. Imp. gal.
Edmonton	54,000	58	26.2	10.1	94.3
Lethbridge	10,000	102.2	44.7	3	149.9
Medicine Hat	9,309	...	....	....	264
Redcliff	2,183	66.4	22.4	....	88.8
Stettler	1,200	10.7	....	....	10.7
Claresholm	1,092	72.6	8.7	5.5	86.8
Bassano	650	....	....	....	211
Athabaska	500	27.6	....	....	....
Carmangay	400	29.8	....	I	30 8
Saskatchewan.					
Regina	35,000	56.9	11.1	.1	68.1
Saskatoon	25,000	27.1	17.2	2.4	63.1
Moosejaw	20,000	31.6	15.4	....	47
North Battleford	4,000	10	4.8	3	26.3
Weyburn	3,100	26.4	....	....	26.4
Estevan	2,100	9.3	.7	7.2	17.2
Kamsack	1,600	31.6	66.5	....	97.9
Battleford	1,500	8.5	....	....	8.5
Kindersley	1,000	6	8.9	....	14.9

Labor Cost of Constructing Monolithic Concrete Sewers

By D. B. DAVIS,

City Civil Engineer, Richmond, Ind.

The following data show the labor required and the procedure followed in constructing a 18-in. diameter monolithic concrete sewer in Richmond, Ind., on which semi-circular forms were used. The contractor had 100 lin. ft. of the half circle forms, of which he used 50 ft. for invert and 50 ft. for the arch. The concrete was machine mixed; the wheel being about 100 ft. from the mixer to the forms. The men were good workers.

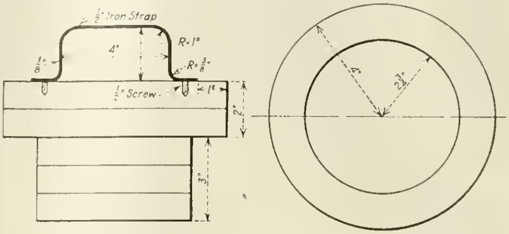


Fig. 1—Hard Wood Forms for Sewer Connection.

The order of the day's work was as follows:

6:30 a. m. to 9:30 a. m.—Sliding invert forms ahead and setting.
9:30 a. m. to 11:15 a. m.—Pouring concrete invert.
11:15 a. m. to 2:30 p. m. (1 hour for dinner)—Moving and setting arch forms.
2:30 p. m. to 4:00 p. m.—Pouring concrete arch.
4:00 p. m. to 5:30 p. m.—Pouring flow-line strip 2 ft. wide.

The labor required for day's run of 50 ft. of sewer was:

	Total labor. Hours.
Invert forms—8 men in gang	24
Pouring invert—12 men in gang	21
Arch forms—6 men in gang	13
Pouring arch—10 men in gang	15
Pouring base strip—10 men in gang	18
Total labor, hours	91

Or 1.82 labor hours per lineal foot.

The organization of concreting gang was:

2 men spreading and tamping concrete about forms.
3 men shoveling gravel in mixer.
4 men wheeling concrete a distance of 100 feet.
1 man running concrete mixer.
2 men setting metal, etc.

The extra men used for pouring concrete were taken from the gangs doing excavation.

The following data shows the labor required to build a 48-in. diameter monolithic sewer, using complete circular forms. The contractor had six sections of form, each section was 6 ft. long. When these were assembled it made a length of 35 ft. The concrete was machine mixed and the wheel for concrete was about 90 ft. The workmen were exceptional and the conditions good.

The labor required for a day's run of 35 ft. of sewer was:

4 men working 2½ hours each removing and resetting six sections of complete circular forms, or total of .... 10 hours

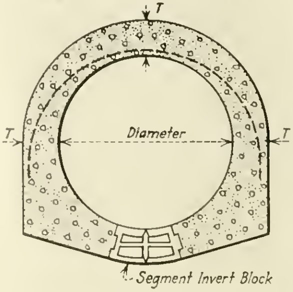


Fig. 2—Standard Plan of Monolithic Concrete Sewer.

Inside diameter. In.	Thickness "T." Ins.	Size of rib metal.	Length of sheet. Ft.	Volume concrete. Cu. ft.
36	4	8	7	3.5
42	4	6	8	5.0
48	5	6	9	7.3
54	5	5	10	8.5
60	6	4	11	11.2
66	7	4	12	14.3

4 men working 6 hours each and 7 men working 2 hours each pouring concrete for complete circle and for flow-line strip, changing runs, etc., or total of	38 hours
Total labor required for 35 ft.	48 hours

Or 1.37 labor hours required for each lineal foot.

The labor required to build 175 ft. of 42-in. monolithic sewer, using the complete circular forms with the same gang as above, was:

	Hours.
First day's work, poured flow-line	16
Second day's work, built 35 feet complete sewer	30
Third day's work, moving forms (rain)	10
Fourth day's work, built 35 feet complete sewer	35½
Fifth day's work, built 35 feet complete sewer	30¼
Sixth day's work, built 35 feet complete sewer	31½
Seventh day's work, built 35 feet complete sewer	30
Total labor for 175 lin. ft. sewer	183¼

Or 1.05 labor hours required per lin. foot.

In building 245 ft. of 36-in. monolithic sewer using complete circular forms, the gang built 35 ft. of sewer each day. It required 31½ hours each day for 7 days or total of 220 hours. Or 0.90 labor hours required per lineal foot.

It will be observed that it requires approximately the same number of labor hours on the form labor for the 36-in., the 42-in. and the 48-in. diameter sewers.

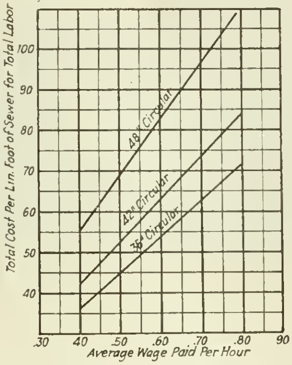


Fig. 3—Labor Cost of Building Monolithic Concrete Sewers Using Complete Circular Steel Forms.

Assumptions:
36 in. diam. requires 0.90 hours per lin. ft.
42 in. diam. requires 1.05 hours per lin. ft.
48 in. diam. requires 1.37 hours per lin. ft.

Figure 1 shows the wooden forms used in making the openings for house connections. This form is made by nailing together two circular blocks, the larger of which moulds the shoulder on which the house connection rests.

Figure 2 shows the standard plan of monolithic concrete sewer construction in Richmond, Ind.

Figure 3 shows plat of curves which show the cost per lineal foot of labor to construct a 36-in., 42-in. and 48-in. sewer.

General Advantage of Pulverized Fuel.—The advantages of pulverized fuel were summarized as follows by Mr. F. P. Coffin of the Research Laboratory of the General Electric Co., in the General Electric Review:

1. Flexibility of control of both fuel and air, and ability to extinguish instantly.
2. Complete combustion, even at high rates of burning, and elimination of smoke.
3. Burning fuel in suspension eliminates the usual troubles resulting from the formation of clinkers.
4. Low-grade fuels may be burned efficiently regardless of the proportion of ash, sulphur or other impurities.
5. Very little excess air is required, which reduces the stack loss and the power required, and also the areas of flues and stacks.
6. Maximum fuel economy is made possible in many applications.
7. The expense of supplying coal to scattered industrial furnaces is reduced to a minimum. Pulverized fuel has semi-fluid properties; it flows easily and can be transferred through pipes:
   a. By screw conveyors.
   b. In a mass by means of compressed air.
   c. In suspension in a current of air.

Surges and Currents in the Gaillard Cut of the Panama Canal

Studies of the currents and surges set up in Gaillard Cut and parts of Gatun Lake adjacent to the north end of the cut by drawing water from the cut to fill the chambers at Pedro Miguel Lock, have been made by the Section of Hydrography and Meterology. The results are summarized in the Panama Canal Record. With respect to the effect on navigation it has been determined that:

The currents that accompany these surges are generally too feeble seriously to hinder navigation. The currents toward Pedro Miguel are much stronger than the return currents toward Gamboa. Only the former need be considered as constituting a possible danger to navigation. Vessels are required to navigate the Gaillard Cut section of the canal at slow speed (not over 6 knots). With the precautionary measures that are taken and moderate currents experienced, no serious accidents to navigation have occurred in Gaillard Cut, and but few minor accidents.

In the case of a restriction of a cross-section, as for instance by a wrecked hull or a slide, the current and wave effects would assume values that would make rapid filling of Pedro Miguel Lock unsafe for navigation in the cut. That is, either no water should be drawn during the passage of ships in the cut, or the culvert valves should be only partly opened so as to draw water slowly.

These surges have a maximum range in height from trough to crest of nearly 3 ft., i. e., the highest crest levels are nearly 1.5 ft. above mean lake level and the lowest troughs are about the same distance below the average level of the lake. These changes in the surface level of the lake due to surges may affect navigation when the lake is down to its minimum operating level by reducing the navigable depth of water in the canal approximately 1.5 ft. at the trough phase of the surge. When the lake stands at or near its maximum operating level there would be a tendency for the water to spill over the lock gates into the lock chambers and machinery pits at the crest phase of the surge. This tendency is not important as the gates and masonry walls at the upper end of Pedro Miguel Locks were built higher than the maximum operating level to prevent spilling over.

Description of Surges.—The surges have been recorded on hydrographs at Pedro Miguel, adjoining the upper entrance to the east chamber; at Gamboa, at the opposite end of the cut; at Juan Mina, 4½ miles up the valley of the Chagres, at approximately right angles to the axis of the cut; and at Gatuncillo, 3 miles beyond Juan Mina, and near the head of backwater on the river. They have also been noticed as far as 6 miles beyond Gamboa, along the axis of the canal. In a series of observations it was found that the surge traveled from Gamboa up the Chagres River arm of the lake in opposition to an inflow of water approximating 1,260 c.f.s. A considerable freshet, however, on the river will wipe out the surges on the Chagres arm of Gatun Lake.

The cut, ending in Pedro Miguel Lock, is 6.97 nautical miles, or slightly over 8 statute miles, in length. The immersed portion of the cut prism is theoretically 300 ft. wide by 45 ft. deep at lake elevation 85 ft., a cross-sectional area of 14,500 sq. ft. Due to removal of slides there are many places which have a greater cross-sectional area than this. To cut down current velocity in the neighborhood of the lock the canal was excavated 600 ft. wide, tapering to 300 ft. at a point 4,300 ft. from the lock.

A filling of a complete chamber with Lakes Miraflores and Gatun, at elevations of 54 ft. and 85 ft., respectively, requires about 3,800,000 cu. ft. of water in a lockage. The wall culverts have minimum clear openings of 255 sq. ft. If both a side and center wall culvert are opened a lock chamber is filled in 7½ minutes. If a side culvert only is used, 13½ minutes are necessary. Thus there are about 8,440 and 4,690 c.f.s., respectively, being drawn, according to whether 2 or 1 culvert is drawing water. If both chambers are receiving water simultaneously, with all 3 culverts open, there are 7½ minutes in which water will be drawn at the rate of 13,130 c.f.s. This is the maximum case; and while such operation does not often occur, it would theoretically give a uniform velocity of about 1 f. s. or nearly 0.6 knot an hour in the cut during a draft of water. This flow is not uniform.

Surges from Lockages.—When the valves are opened the canal basin above the locks rapidly falls in elevation (sometimes as much as 1.5 ft., according to the number of valves open). The inertia of rest of the canal water plus the friction from the sides and bottom of the canal, prevents an immediate response to the tendency for a flow of water to set up toward the lock.

When the valves are closed and the effect of the difference in elevations overcomes the tendency for a retardation of flow in the cut, an acceleration sets up, which results in a surge of over-travel, the crest of which is as much above the original lake level as the depression was below. Equalization of levels is finally reached after a series of wave amplitudes, with decreasing intensities, unless their movement is complicated by another lockage.

A study of the hydrographs shows that from crest to trough the oscillations at all stations are about 45 minutes apart. Examination of many such hydrographs have shown this definite period occurs daily. During the six lockages of Aug. 3, 1911, the average period of time between the same phase of the surges at each station was as follows:

(a) Effect of opening valves at Pedro Miguel Lock appears on the Gamboa hydrograph in 18 minutes; at Juan Mina, in 60 minutes; at Gatuncillo in 78 minutes.

(b) The effect of closing valves at Pedro Miguel Lock appears at Gamboa in 19 minutes; at Juan Mina, 60 minutes; at Gatuncillo, 82 minutes.

(c) The peak of the return surge after the closing of the valves is observed at Gamboa 25 minutes after it appeared at Pedro Miguel; at Juan Mina in 65 minutes; and 87 minutes afterward at Gatuncillo.

When the crest phase of a wave is at Pedro Miguel a trough phase is approximately at Juan Mina, and vice versa. The relative heights of successive waves at the various stations vary somewhat, but the wave at Gamboa averages about ⅛ the height of the wave at Pedro Miguel. Wave heights at Juan Mina are about the same as those at Gamboa, while at Gatuncillo at the head of the Chagres River arm of Gatun Lake, the wave heights are approximately 50 per cent greater than at Gamboa or Juan Mina.

Effect of Irrigation on Crop Yields

Crop increases ranging from 51 per cent to 105 per cent were obtained at the Canadian Government experimental farms at Lethbridge, Alberta, by irrigation. The following table abstracted from the 1918-19 report of the Reclamation Service Division of the Dominion Department of the Interior shows the comparative results for crops grown on dry and irrigated lands, the figures being the average for the 11-year period 1908-1918:

	Bushels per acre.		Increase due to irrigation.	
	Dry.	Wet.	Bu.	Pct.
Wheat (Marquis)	30	53	23	77
Oats (Banner)	70	108	38	54
Barley (Swedish Chevalier)	43	78	35	81
Peas (all varieties)	27	41	14	51
Potatoes (Irish Cobbler)	237	487	250	105

The experimental farm is bisected by an irrigation ditch so that a part of the farm is above the ditch and is dry farmed and a part is below the ditch and is irrigated. The figures shown have been very carefully selected, showing the actual results gained during the 11 years on crops where the only difference was between dry land and irrigated land. There was no special attempt made to get results that would show the difference between dry land and irrigated land—the aim was to develop methods for gaining the best results both on dry and on irrigated land. The crops were grown on small plots under very careful cultivation, so that all the yields are probably higher than produced on the average farm; but the difference between the yields should be the same as on an ordinary farm. The last column speaks for itself in showing the average increase over 11 years—some wet and some dry—due to irrigation. And further, all the dry crops were produced on summer-fallow, which requires that for every acre producing a crop in any year another acre is lying fallow. The irrigated land produced a crop under rotation every year. Therefore to get a true comparison between the dry and the irrigated land the figures in the last column should be doubled.

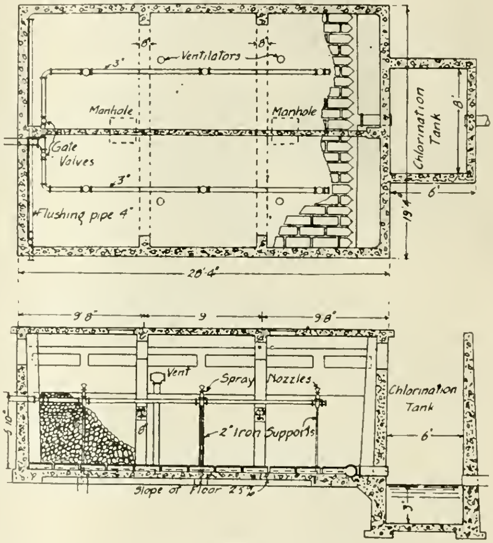
Hospital Sewage Treatment Plant

A sewage treatment plant of somewhat unusual design was recently constructed for the Mowat Sanitorium at Portsmouth, Ontario. The installation is described in a recent issue of The Contract Record, from which the following details and costs are taken:

The plant is designed to treat the sewage from 300 inhabitants of the hospital. It consists of an Imhoff tank, siphon chamber, sprinkling filter and sludge bed. Provision for chlorination is included and will be added in the near future.

The Imhoff tank is of reinforced concrete 20 ft. by 9 ft. in plan and with a depth of 15 ft. from the flow line to the bottom. The period of retention in the settling compartment is from 1½ to 3 hours and the capacity of the sludge compartment is sufficient for about 5 months. The bottom of the tank is divided into two inverted pyramidal compartments. Baffles are placed at the inlet and outlet ends of the tank.

The siphon chamber is 5½ ft. long by 5 ft. wide, inside, and has a pyramidal bottom. The capacity is 200 gal. and is operated by a 5-in. Miller siphon discharging into a 6-in. pipe leading to the sprinkling filter with a maximum head of 7 ft.



Details of Sprinkling Filter.

The siphon chamber is constructed as part of the sedimentation chamber.

The sprinkling filter is a reinforced concrete structure, 26 x18 ft. inside. It is divided into two longitudinal compartments by a concrete wall. The floor has a 2½ per cent fall towards the outlet end, and the underdrains consist of 5 in. half-round tiles resting in grooves. The filtering material is 5 ft. thick and varies from 5 in. to ½ in. stones. Six Taylor square spray type nozzles distribute the sewage from 3 in. galvanized iron pipes. On account of the extreme cold during the winter and the cessation of flow during the night, it was thought best to provide a house of reinforced concrete and heat it with a stove.

The sludge bed has an area of 400 sq. ft. and the depth of the filtering medium is 3 ft. The sludge is carried onto the bed through a vitrified clay pipe.

The plant has been in operation for four months and is said to be producing a clear effluent, although no analyses are available at present.

The cost of the entire system was $11,800, and includes the building of 2,600 lin. ft. of 6-in. sewer, 1,600 lin. ft. of ditch for surface water, and the building of the tanks, etc., as follows: 590 cu. yd. of rock excavation; 1,044 cu. yd. of earth excavation; 1,100 cu. yd. of back filling (earth and stone); hauling 275 cu. yd. of excavated rock 1,500 feet away; 2,600 lin. ft. of sewer trench, part 7 ft. deep in rock; 1,600 lin. ft. of trench 18 in. deep for surface water; 11 concrete manholes; the reinforced concrete tank and filter house and sludge bed.

The excavation for tank, 18 ft. in depth, was in solid rock. In that cost of $11,806 is not included the salary of the engineer in charge.

Coefficients of Discharge of Sewage Sprinkler Nozzles

The determination of the coefficients of discharge of several makes of sprinkling filter nozzles was the object of a series of experiments conducted in the hydraulic laboratory of Purdue University. The results of the tests were published recently in Bulletin No. 3 of the Engineering Experiment Station of the University. The following notes on the experiments are from this bulletin:

The sewage-sprinkler nozzles used in these experiments were all that could be obtained of the standard commercial types. Each nozzle has been designated with a number for the sake of convenience. The nozzles have been listed as "square" or "round" according to the shape of the orifice, or discharge opening. The nozzles are shown in the accompanying illustration, the notation thereon referring to the following:

Sprinkling Filter Nozzles Used in Purdue Tests.

No. 1. Chase square nozzle.
No. 2. Taylor round nozzle.
No. 3 Taylor square nozzle.
No. 4. Worcester round nozzle, 13/16-in. orifice.
No. 5. Worcester round nozzle, 11/16-in. orifice.
No. 6. Merritt square nozzle.
No. 7. Priestman-Beddoes round nozzle.
No. 8 Weand "Atlantic" type round nozzle.

The following table gives the dimensions of the discharge openings determined with a micrometer.

Nozzle No.	Diameter nozzle orifice. In.	Diameter spindle. In.	Net area discharge. Sq. in.
1	....	.354	.5016
2	.899	.367	.5290
3	.899	.393	.5135
4	.813	.192	.4901
5	.703	.163	.3673
6	.863	.396	.4617
7	.750	.361	.3394
8	.935	.371	.5785

The base of the nozzle is the large end through which the water enters. The opening in the smaller, or discharge end, is the orifice. The spindle is the rod which supports the cone for affording proper distribution of the discharged water. In nozzles Nos. 1 to 6, inclusive, the spindle and cone are in one piece. In the other two nozzles, the cone works along a threaded spindle and may be set in any desired position. The area of the orifice minus the cross-sectional area of the spindle is the net area of discharge.

The arrangement of the apparatus was as follows: Water for the nozzles was obtained form a centrifugal pump through a suitable system of piping, in the discharge end of which was a vertical 4-in. pipe, 8 ft. long. At the upper end of the 4-in. section was a 4 to 3-in. reducer, followed by a 3 to 2-in. reducer into which the nozzles were screwed. A ¼-in. pipe gave connection from a point just below the base of the larger reducer to a water piezometer. This piezometer was 12 ft. in height and consisted of three pieces of glass tubing held together by rubber tubing and tarred tape, the whole being mounted upon a 2x6-in. plank. A cloth tape graduated to hundredths of a foot was placed immediately behind the glass. The elevation of the water column could be read directly to thousandths of a foot with the aid of an index pointer and attached vernier.

No difficulty was experienced in maintaining a constant head. The water discharged from the nozzles was collected in an open box 4 ft. square, which was made to serve the purpose of a large funnel. The floor of the box, made watertight by a covering of metal sheathing, sloped from the center towards the sides and was provided with a drain pipe so as to afford a ready outlet for the discharged water. This drain pipe was so supported on a bracket that it could easily be moved by means of a rope attachment so that the discharge therefrom could be directed either into a weighing tank or into a waste channel.

The cylindrical weighing tank had a capacity of 600 lb. and rested on a Fairbanks platform scales of 3000 lb. capacity. The weight of a cubic foot of water was taken as 62.32 lb.

The total head acting on a nozzle was the pressure head, or elevation of the water column in the piezometer above the base of the nozzle. The velocity of approach was negligible.

The piezometer reading for zero head was obtained by first noting the reading of the piezometer when the water stood level with the top of the orifice and then subtracting a correction equal to the distance from the base to the top of the nozzle.

Each nozzle was tested under heads ranging from 1 to 11 ft. The flow was regulated by a valve placed in the line leading from the pump. Five readings were taken on the piezometer for each run, the average of which, minus the zero head correction, was assumed to be the mean head. Other data recorded were: time, initial and final weights of discharge, and the temperature of the water. The temperature remained practically constant and was not considered in the computations.

The following nomenclature was used:

Q = Theoretical discharge in c.f.s.
a = Net cross-sectional area of opening in sq. ft.
h = Pressure head in feet of water.
g = Gravity = 31.16.
q = Actual rate of discharge in c.f.s.
C_q = Coefficient of discharge.

The theoretical rate of discharge for any nozzle may be represented by the equation. $Q = a\sqrt{2gh}$. It follows therefrom, that the actual rate of discharge is $q = C_q a\sqrt{2gh}$ and the coefficient of discharge is $C_q = \frac{q}{a\sqrt{2gh}}$. The graph which shows the relation between the logarithm of the head and that of the discharge is, with the exception of nozzle No. 8, a straight line.

About 176 tests were made in all and the following coefficients of discharge for heads above 1.5 ft. were determined:

Nozzle No.	1	2	3	4	5	6	7
Cq	.648	.756	.696	.666	.675	.598	.569

The coefficient for nozzle No. 7 is with the base of the cone level with the top of the orifice.

The conclusions reached are that the coefficient of discharge remains constant for all nozzles except No. 8 when the head is greater than 1.5 ft.

Cost of Sewer Construction at Providence, R. I.—The following tabulation from the last annual report of M. H. Bronsdon, City Engineer of Providence, R. I., shows the average depth of cut, nature of excavation, and contract cost of labor per foot, on the different sizes of regular sewers built in that city during 1918:

Items.	Average nature of excavation.	Av. depth of cut, ft.	Average cost per foot.
6-in. pipe in drains to curb line	Sand, dry	10.50	$0.85
6-in. pipe in drains to curb line	Sand and gravel, dry	10.50	1.00
6-in. pipe in drains to curb line	Sand, gravel and boulders	10.50	.50
6-in. pipe in drains to curb line	Rock	10.50	2.87
8-in. pipe in basin connections	Sand, dry	8.00	.75
8-in. pipe in basin connections	Sand and gravel, dry	8.00	.80
8-in. pipe in basin connections	Sand, gravel and boulders	8.00	.50
8-in. pipe in basin connections	Rock	8.00	1.00
12-in. pipe in sewer	Sand, dry	12.00	1.50
12-in. pipe in sewer	Sand and gravel, dry	12.00	1.92
12-in. pipe in sewer	Sand, gravel and boulders	12.00	2.50

POWER AND PUMPING SECTION

This section of the Waterworks and Hydraulic Monthly issue of Engineering and Contracting is devoted to the selection of power and pumping equipment and the economic management of its operation.

Purchase of Coal on Specifications

The more essential features which should be covered in the specifications for coal to be purchased on a heat value basis were outlined by Mr. John Howatt, Chief Engineer Chicago Board of Education, in a paper presented before the Western Society of Engineers. An abstract of the paper follows:

Before a consumer should make any attempt to prepare a specification for coal he should try out coals of different sizes and from different coal fields in his boiler plants and obtain information thereby as to what size of coal gives the best results and find out from what fields the coal can be used successfully in his furnaces. Analysis of each coal tried should be obtained. The consumer will then be prepared to specify the size of coal desired and place limits for ash, moisture and heat value, as the basis of a scientific specification for future purchases on the B. T. U. basis; and if the coal is specified further to be free of excessive clinkering and free burning, the purchaser should be in a position to place contracts for coal not necessarily on the lowest price per ton as bid, but the lowest cost to him for the year's fuel supply, which should in general be the determining factor from the purchaser's standpoint. Of course, it may be advisable on account of weak furnace draft or insufficient boiler capacity to purchase the highest grade coal for some plants regardless of the fact that the price per unit of heat value may be higher; and the selection of coal for stocking or placing in storage must be based on considerations other than costs; but in general the net cost of fuel per season should be the governing factor for purchasing in quantities under normal conditions. The work done by Prof. Parr of the University of Illinois in his studies and analysis of Illinois coals should be of great assistance in the preparation of specifications for Illinois coals and in the selection of the proper coal to use.

Taking it for granted that all the coals considered in making a selection are free burning and free from excessive clinkering, there are but three things the purchaser of bituminous coal needs to know about it; they are its ash content, its moisture content and its heat value or B. T. U. per pound. All formulas used, therefore, in specifications covering the purchase of bituminous coal on the heat value basis should contain the three factors: ash, moisture and B. T. U., the first two being loss factors and the last a credit factor on each pound of coal. This taking the coal apart as it were and studying what should be charged against each portion of it; a sort of a cost analysis of each pound of coal.

Ash Content.—All of the non-combustible material left after coal is burned off in the furnace is known as ash. The percentage of ash in coal varies greatly in the different sizes from the same mine, depending upon the part of the vein the coal is taken from and the mine operations. It is greatly increased by the presence of earthy material, slate, stone or shale, and is highest in the fine coal from the bottom of the vein or from the bottom of a shipment. Screened lump and nut coals, therefore, contain the lowest percentage of ash, and fine coal and screenings contain the highest ash content; in fact screenings may and often do contain twice as much ash as nut coal from the same mine. Ash is a factor that may materially reduce the value of a mine output, and as it can be reduced by careful operation and by careful washing, consideration should be given by the mine operator improving or conserving the natural value of his output by keeping the ash content low.

The purchaser must bear in mind that the ash content in coal is very important to him, and if he be wise he will make provision to protect himself against paying for a large tonnage of ash that is a loss to him. For illustration, if the purchaser pays $5 per ton for coal delivered into his bunkers, he is also paying $5 per ton for the ash in the coal. To this must be added the cost of handling and disposing of ashes from the furnace. This will vary in different plants, depending upon the equipment provided for ejecting or moving the ashes from the ash pit, and depending upon what must be done with them afterward. Some plants are so located the ashes can be sold or used to advantage for filling; others are located in congested, built-up districts where ashes have to be teamed to dumps several miles. It is costing an average of $1.20 per ton for hauling ashes away from the public schools of Chicago in 1919. Assuming, therefore, an average cost of 50 ct. per ton for ejecting ashes and $1.20 per ton for hauling them, the total cost of the ash to the purchaser of $5 coal would be $6.70 per ton. This is a direct cost and the value received is zero. It is readily seen what a difference there is in the value of a ton of coal of 10 per cent ash over a ton of coal of 20 per cent ash; the purchaser will pay 67 ct. for the ash in a ton of 10 per cent coal and $1.34 for the ash in a ton of 20 per cent coal. If the purchaser is to be protected, therefore, the method of purchase should be one that will make the difference in the cost of a ton of coal to him carry the loss due to the increased ash content.

Besides the loss in theoretical heat value of coal because of its ash content, there is a further actual loss in practice when the ash percentage exceeds a certain limit by reason of the loss in capacity and efficiency of the furnaces on account of clogging of the fires from the ash deposit. In fact, coal containing 30 per cent ash cannot be burned at all in many plants and thus has no value. During the coal shortage in the winter of 1917 the writer had experience with screenings that tested 32 per cent ash. These screenings would not burn on a chain grate until they had been mixed with a No. 3 nut coal of low ash percentage.

In preparing specifications for coal to be purchased on a test basis, therefore, a maximum limit on the percentage of ash should be named, and a penalty for the ash content in coal over the maximum should be provided, heavy enough so very little such coal would be furnished. The penalty should be on a scale that increases rapidly as the percentage of ash increases. If the ash content is lower than the limit named in the specifications, the contractor should obtain an increased price per ton corresponding to the increased value of the coal.

Were it not for the fact that very frequently coal has to be burned before the result of the test analysis is known, coal exceeding the limits in ash should be rejected, as price adjustment will seldom compensate the purchaser for all of his loss. The rejection of coal purchased on specifications is generally impracticable after delivery has been made, so resort must be had to a heavy penalty for protection.

Two typical specifications making provision for price adjustment to take care of the ash content in coal are noted for illustration, as they represent the latest practice on purchasing coal on a test basis. One is that used by the United States Government and the other is that used by the city of Chicago. In the specifications upon which the government purchased its coal in 1919, what is termed a standard ash value on a dry basis for the quality of coal it is intended to purchase was established. For any coal received that tests a lower percentage ash than the standard named, the contractor is allowed a bonus of 2 ct. per ton of coal for each per cent the ash is less than the standard. This seems to be based upon a cost of $2 per ton for handling ash. No penalty for ash is deducted unless the ash content is more than 2 per cent greater than the standard. Where the ash content is more than 2 per cent in excess of that named as standard, deductions are made from the price to be paid for the coal on a rapidly ascending scale to compensate for the loss in efficiency in the furnaces. In the specification used by the city of Chicago a deduction of ½ ct. per ton of coal for each per cent of ash on a dry basis is made on the entire ash content. This is based upon a cost of 50 ct. per ton for handling ashes and does not increase the penalty for excessive ash to compensate for the loss in furnace efficiency, and therein does not protect the purchaser against coals delivered with a high ash content as well as does the specification used by the government. On the other hand, it makes a deduction for all the ash in the coal instead of only that in excess of the limits, and in that regard is more scientific but not as practicable in application at the present time.

Moisture Content.—Moisture is the other inert content in the coal that the purchaser has to pay for and for which he receives no return. Unlike ash, however, he does not pay to have it removed. There is a question as to whether the moisture is of enough value in the coal to compensate for the loss of heat units in evaporating it in the furnace. Formula used in purchasing coal on a B. T. U. basis as a rule makes no penalty for moisture other than that provided by reducing the coal delivered to a dry basis, by which is meant —from which all moisture is driven out.

Moisture is a factor that changes rapidly. A car of coal may gain or lose a ton of moisture en route from the mine to the consumer, fine coal taking on and giving up moisture most rapidly. It is important, therefore, that for the protection of both the buyer and seller, a coal sample for moisture test should be taken when the coal is weighed at the delivery point. If the coal takes on moisture after being weighed but before being sampled, the contractor will be the loser; but if the coal gives up moisture after being weighed but before being sampled, the purchaser will then be the loser.

The two typical specifications considered before, that used by the government and that used by the city of Chicago, differ in their provision for adjustment of price because of moisture only in their method of application. The government specification provides for a payment based upon the British thermal units in the coal as received, the B. T. U. per pound of coal will thus be automatically reduced in proportion to the amount of moisture in it. The city of Chicago specification provides for payment upon the British thermal units in the dry coal, but reduces the amount of coal paid for by the amount of moisture in it. The resultant number of heat units in a ton of coal and the price paid the contractor therefor would be identical under either specification.

Heating Value.—Coal is purchased for its heating value, for its ability to convert water into steam, and a measure of this value is a measure of the worth of the coal. The unit of heating is the British Thermal Unit, being the heat required to raise 1 lb. of water 1° F., and the heating possibility of any coal is measured by the number of such heat units in a pound; as the B. T. U. per pound varies as much as 30 per cent between the different commercial Illinois coal, it may be seen that the purchaser can secure what he pays for, heating value, only through a method of purchase that bases payment on the B. T. U. per pound of coal. This is the most important factor in all coal purchases made upon analysis, and in fact such purchases are usually referred to as purchases "on the B. T. U. basis."

In writing proposals for coal to be purchased on a B. T. U. basis, limits for B. T. U. per pound should be named far enough apart so there will be plenty of opportunity for competitive bidding and still limiting the coal to the general quality desired. In comparing bids the lowest bid is determined, as in government specifications, from the cost per million B. T. U. obtained by: multiplying bid price per ton by one million and dividing by 2,000 times value of the B. T. U. per pound as established by the bidder; or as in the city of Chicago specifications, the number of B. T. U. for one cent, obtained from the bidder's proximate analysis of the coal he proposes to furnish as follows:

$$\text{C. B. T. U.} = \frac{\text{B. T. U. Dry Coal} \times \%\ \text{Dry Coal} \times 2{,}000}{\text{Bidder's Price Per Ton in c.} + (.5 \times \%\ \text{ash})}$$

Determination of Price.—The determination of price to be paid for coal purchased on the B. T. U. basis is a very simple matter after analysis is known, but of course must follow the provisions in the specifications under which the contract is executed. Again consider for illustration the two typical specifications: that of the government and that of the city of Chicago. Price adjustment, government specifications, is made as follows:

$$\frac{\text{B.T.U. in coal as received} \times \text{bid price}}{\text{B. T. U. established by contractor}} = \text{Price adjusted for B.T.U.}$$

This price is then subject to further adjustment, up or down, depending upon the percentage of ash found in coal in accordance with a table.

Price adjustment on city of Chicago specifications is made in one formula, as follows:

$$\text{Price} = \frac{\text{B. T. U. Dry Coal} \times \%\ \text{Dry Coal} \times 2{,}000}{\text{C. B. T. U}} - 0.5 \times \%\ \text{ash (as cts.)}$$

Formulæ as simple as these may be prepared to conform with terms of any specifications.

Sampling.—The operators in general are not in favor of selling their coal on the B. T. U. basis. Why? I have talked with operators of mines whose output is of high quality and who should receive a comparatively good price per ton for their coal if sold in accordance with heat value, and with numerous jobbers and dealers, and all seem to object to the B. T. U. method of purchasing coal because of their fear of the sampling of the coal. It is a fact that the securing of proper samples for analysis is the most difficult part of the entire operation. There have been rules established governing the taking of samples which are explicit enough, and if strictly followed would result in fair samples being taken, yet it is easy for the sampler to be careless or even dishonest with results in favor of either contractor or purchaser. A careful selection of samplers of intelligence and unquestioned integrity is the best safeguard for both parties.

The fundamental rule governing the taking of samples is that they shall be fairly representative of the entire lot of coal. Much has been written about the proper method of obtaining and dividing such representative samples. The latest bulletin on the subject is technical paper No. 133, published by the Bureau of Mines and prepared by George S. Pope. This paper very fully describes and illustrates the proper method of sampling coal, whether delivered by wagon, car or ship load. When it is considered that a pile of coal consists of a mass of lump, bone, slack and earthly matter and that the fine coal contains a higher percentage of impurities or ash than does the large lump, the difficulty in obtaining a representative sample may be appreciated. The larger the sample, of course, the less will be the percentage of error, and the sample would have to be larger in coal of lump size than it would be in screenings or small nut. Even in careful sampling there will be some error in individual lots, but with honest, conscientious samplers this error will be practically eliminated through the law of averages where a number of lots on same contract are sampled and results averaged.

Failure to Comply with Specification.—If the contractor is making a good profit on his contract little trouble need be expected. It may be, however, that a contractor will lose money, and unless he is an honorable contractor with sufficient means to carry him through, trouble may then be expected. The specifications should be very specific as to under what conditions the purchaser has the right to reject a delivery of coal and under what conditions there may be a forfeiture of the contract. The specifications also should provide under what conditions the purchaser has the right to obtain coal from a dealer other than the one with whom he has the contract, and charge the difference in cost, if any, against the contractor's account. Controversy may arise during the life of any contract, and it has been my experience that the purchaser's rights on these points should be strictly guarded. Contracts should be prepared with teeth in them so they will be effective and not merely scraps of paper.

Engineers' License Bill Before New York Legislature.—Senate bill 1258, introduced in the New York Legislature by the New York Chapter of the American Association of Engineers, which provides for the licensing of professional engineers and land surveyors in the state of New York, was endorsed by the New York Section of the American Society of Civil Engineers on March 31 and by the Brooklyn Engineers' Club on the following evening. Both of these organizations have appointed committees to work in the interest of the bill. The bill has also been approved by the Albany Society of Civil Engineers and by the other chapters of A. A. E. in the state of New York.

Milwaukee Power Plant to Be Equipped to Burn Pulverized Coal*

Through many vicissitudes pulverized coal in the power plant has at least reached the stage where it may be pronounced a commercial success, although there still remains much experimental work to be done. The numerous difficulties that have blocked the way have been overcome gradually, and it has been proved beyond peradventure that coal in the powdered form can be burned to advantage over the most modern and recent methods of combustion. The general increase in the price of fuel has been the immediate incentive. Under test conditions the efficiency of burning is only a trifle higher than in the modern type of stoker, but in daily operation the elimination of the many variable conditions entering into stoker operation, the flexibility and the ease of control and other inherent advantages are reported to give to powdered coal a margin that will more than offset the higher cost of fuel preparation and the additional investment in equipment.

The glory goes to Milwaukee and in particular to the men who have struggled for two years to make the previous claims possible. It has not been an easy task, and there were times when the difficulties seemed almost insurmountable. Five times the furnaces were changed in shape and volume, and additional provision made for the admission of air to improve combustion and protect the brickwork in the furnace before the present satisfactory results were obtainable. The furnace volume selected 0.359 cu. ft. per square foot of water-heating surface, is not excessive when it is considered that it is equivalent to the furnace and ashpit of a stoker.

Re-equipping five boilers in an old plant made the work more difficult than it would have been with an original layout. The proof of the pudding is in the eating, and in this case the verdict has been so favorable that the new Lakeside plant of the Milwaukee company will be equipped to burn pulverized fuel. As an initial installation it is to have eight 1,306-h.p. boilers, two 20,000-kw. generating units and a separate building for the preparation of fuel. The coal consumption will approximate 700 tons per day. The added investment in building and equipment for preparing the fuel over a stoker plant has been estimated to exceed $20 per boiler horsepower, but the saving possible, based on improvements, suggested by operation at Oneida St. station, indicates that this additional expenditure will be well worth while. A more exact statement of the possibilities will be available at a later date.

Referring again to the opinions of the men responsible for the progress made and of those who had an opportunity to inspect the plant at its present stage of development, it would appear that boiler-room operation when burning powdered coal is much simpler than with a stoker installation. The rate of steaming is controlled by varying the speed of the feeder motor and adjusting the damper for the variation in the quantity of flue gas. It is unnecessary to correct the holes and heavy spots that develop in the fuel bed of a stoker; and variations in kind and quality of fuel burned seem to have no effect on operation except that with a constant feed the rate of steaming will vary with the heat value of the coal. Losses inherent in stoker practice, such as breakdowns in the stoker itself, breaking up and lossening clinkers, watching the fire to maintain uniform thickness, dumping and many other operations, are eliminated. Efficient combustion is maintained without continual supervision by an experienced operator, and from the standpoint of reliability the odds have been placed in favor of pulverized fuel.

With coal and air supplies easily adjustable, almost perfect fire control and proper air distribution are obtained. This results in thorough combustion, uniformly high efficiency under normal operation, and the ability to change from no load to 200 per cent overload in a few seconds. Regularity of action, making it possible to anticipate results, is a factor that appeals to the operator.

With powdered coal, banking a boiler is a simple process, requiring no additional fuel to hold the fire. It is necessary only to stop the fuel supply and close the dampers and auxiliary air inlets. The radiant energy in the brickwork is retained and will hold pressure on the boiler for hours.

Observation for a period of two years in the installation under discussion has demonstrated that the brickwork in a pulverized-fuel furnace will stand up equally as well as in a stoker installation, with the added advantage that ironwork is eliminated from the high-temperature zone of the furnace. Maintenance exists principally in the pulverizing plant. With machinery of the slow-moving type it is not excessive, although there is room for improvement.

Owing to the soft heat and no impingement of the heat on the tubes caused by a strong draft, the formation of scale in the boiler seems to be less. There is absolutely no trouble from smoke and no soot to reduce the heat-absorbing ability of the boiler, although there is some collection of very light ash. Much of the ash apparently floats out of the stack, leaving a comparatively small amount to be removed from the combustion chamber. It is interesting to note that the low moisture content of the coal as fired reduces the opportunity for the formation of sulphuric acid, so destructive to all ironwork with which the flue gases come in contact.

That there has been no serious trouble from coal-dust explosions is attributed to proper care in preventing the coal from being dried too much or pulverized to a fineness beyond the requirements. The drying process requires careful supervision and ability in the operator to recognize and meet the varying properties of the coal as it arrives. Drier operation must be changed to meet variations in size and moisture if a uniform product is to be delivered. Coal that is too dry increases the danger from explosion, and too much moisture induces a tendency toward clogging the system at points most readily affected. At Milwaukee moisture has been one of the bugbears encountered.

No claim is made that perfection has been reached in the present installation or that other designs of equipment might not work equally well or possibly better. Valuable experience has been gained, however, and the next installation will contain a number of improvements. It is felt that something might be done toward reducing the cost of preparing the fuel, especially along the lines of utilizing waste gases for drying in plants not provided with an economizer. A furnace that would burn a large percentage of finely divided coal and still care for a smaller amount of larger-sized particles would be a decided advantage, as it would reduce the work of the pulverizer, which requires about seven-eighths of the total electrical energy consumed by all moving parts of the coal-preparation equipment, and also curtail the labor in this department.

Admission of excess air to prevent slag formation and the destruction of the brickwork tends to lower the CO_2 and reduce to some extent the efficiency of combustion, or at least the absorption by the boiler due to the lower heat head. There is an opportunity here for improvement. A more thorough mixing of the air and fuel in proper proportions before entrance into the furnace may be the solution.

The proper furnace volume per square foot of steam-making surface or per unit of coal burned, the position of the furnace relative to the boiler, the location of the burner, whether vertical or horizontal, the best methods of mixing coal and air, location of equipment, etc., are all factors requiring more study. These are the problems of the future. Suffice it to say that the plant which has been made a success at Milwaukee, has paved the way. The pioneer work has been done. There remain perfection of detail and experimental work to exhaust the possibilities for increased efficiency.

An interesting point is the conclusion that a plant developing less than 2,500-boiler horsepower on a 24-hour operating basis should not consider using powdered coal. The reasons advanced for this limitation are the cost of installation, the relatively small amount of coal pulverized per day and the proportionately large labor charge for operating the preparation plant.

Convention of Mississippi Valley Waterways Association.—The Third Annual Convention of the Mississippi Valley Waterways Association will be held April 19, at the Hotel Statler, St. Louis, Mo. The program includes addresses by J. W. Alexander, U. S. Secretary of Commerce; John M. Parker, Maj. Gen. Lansing H. Beach, and others.

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*From an editorial in Power.

Cost of Operating Diesel Engines at Appleton, Wis., Pumping Station

The power plant at the pumping station of the waterworks of Appleton, Wis., consists of two 225-b.h.p. Diesel engines, which are direct-connected to four 2,000,000-gal., double-acting, triplex pumps, one at each end of the engine shaft. The engines, which were manufactured by Busch-Sulzer Bros.-Diesel Engine Co., of St. Louis, are located opposite each other with parallel shafts, so that the air compressors can be run from either engine. The pumps are thrown into gear with the gas engine by friction clutches, while two 15-kw. generators are driven by link-belt silent chains. The total capacity of one pumping unit, 4,000,000 gal., is sufficient to provide adequate fire protection for the city. The engines are run each on alternate weeks, thus affording one reserve unit at all times. They are operated at a speed of 164 r.p.m. for both fire and domestic use. It is possible to increase the speed to 180 r.p.m. by means of a special device on the governor. At 180 r.p.m. the capacity of the pumps is increased about 10 per cent. Ample check is kept on the operation of the pumps, as all water is measured at the station by a Venturi meter. The running cost of the Diesel engine for 1918-1919 is given as follows in a recent issue of The American City:

Average number gallons water pumped per day	1,640,000
Average number hours operated per day	13.51
Average number gallons fuel oil used per day	128.08
Average number gallons fuel oil used per million gallons water pumped	78.2
Average number pints of cylinder oil used per day	11.18
Average number pints of air compressor oil used per day	.65
Average number pints of engine oil used per day	1.28
Average number pints of kerosene oil used per day	2.21

A chief engineer and three assistants who work on 8-hour shifts, are employed at the plant.

Cost of Electrical Pumping at Kingston, Ontario

Costs for electric pumping in 1919 show a reduction over steam pumping in 1918 for the city of Kingston, Ontario. (Population 22,000.)

The normal growth of the city and the conditions of the existing steam pumps necessitated some additional pumping capacity, according to the Bulletin of the Hydro-Electric Commission of Ontario, from which the following notes are taken:

After careful investigation, it was decided to install an electrically-driven centrifugal pump having a capacity of 3,500 Imp. gal. per minute, against a total head of 210 ft. The pump was to be connected to a 320 H. P. 3-phase, 60-cycle, 2,200-volt, 1,200 R.P.M. synchronous motor.

Statements available covering operating costs during 9 months of 1917 and 9 months of 1919 indicate an average daily pumpage of 3,520,000 Imp. gal. in 1917 and 3,800,000 Imp. gal. for 1919.

The operating costs for the above periods were:

	Per million Imp. gal.
1917 coal at $6.89 per ton	$ 6.51
Oil, waste, supplies, etc	1.55
Labor	3.71
Total operating costs	$11.80
1919 coal banked fires at $7.18 per ton	1.07
Electric power	4.77
Oil, waste, supplies, etc	1.88
Labor	2.73
Total operating costs	$10.43

The above figures indicate a saving of 10 to 12 per cent, or about $1,500 per annum.

600 Ft. Pumping Lift for Irrigation

At Underwood, Wash., 200 acres of orchard and strawberry lands are irrigated by means of a turbine and pump lifting water 600 ft. This, states Mr. J. C. Stevens in the Journal of Electricity, is believed to be the highest pumping lift for irrigation in the Pacific Northwest.

The pump is a 5-stage centrifugal built by the Morris Machine Works of Baldwinsville, N. Y. It is belted to a 24-in. S. Morgan Smith turbine set in an open flume using 60 sec. ft. of water under 18 ft. of head, and revolving at 265 r.p.m. The pump speed is 1,700 r.p.m. and the amount of water raised is 550 gal. per minute.

The pipe line is 5,400 ft. long. It consists of 280 ft. of 8-in national converse steel pipe and the remainder of 8-in. wood stave pipe. The first or lowest delivery of water is under a total head of 150 ft. and the last or highest at 600 ft.

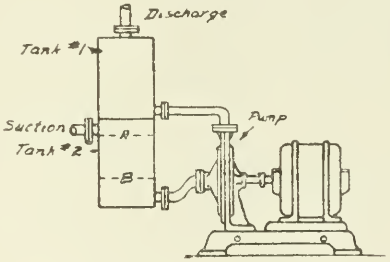
Water power for the turbine is supplied by a flume one-half mile long, diverting water from White Salmon River and developing a total head of from 17 to 22 ft., depending on the stage of the river.

The project was completed by Mr. Stevens in the spring of 1917. Organization was effected under the District Irrigation Laws of the State of Washington. The total bonded indebtedness of the district is $16,500 and the total assessments for interest, maintenance and operation have averaged $8 per acre, while the value of the crops raised has been considerably over $100 per acre each season.

Automatic Primer for Centrifugal Pumps

An automatic primer, claimed to be adapted to any condition where centrifugal or other valveless pumps are used, and where it is necessary to maintain a vacuum on a suction line, has been brought out by the Automatic Primer Co., 420 Conway Bldg., Chicago.

The arrangement is shown in the accompanying diagram. Tank No. 2 is filled with liquid to level A and the pump started. This lowers the liquid to level B but in so doing produces a vacuum in tank No. 2 and starts the liquod flowing through the suction line. While pumping, tank No. 1 is always filled with liquid. When the pump is stopped the liquid in Tank No. 1 returns by gravity to Tank No. 2, forcing the air back through the suction, thus flushing the suction line and repriming the system. Each tank has a capacity approximately one-third greater than the volume of air or gas in the suction line when expanded to the vacuum of operation.



Arrangement of Apco Priming System.

Public Works Financing in 1919

Financing the permanent improvements of American states, counties, cities and towns in the calendar year 1919 absorbed about $750,000,000 of the funds of American investors. This sum, states the Bond Buyer, is a larger amount by over $250,000,000 than the total borrowings of this character in any previous year and is in remarkable comparison with the total for 1918, viz.: $262,818,844. The amount borrowed by states and municipalities in the two years 1918 and 1919 was little in excess of the borrowing in 1916 and 1917 or in 1915 and 1916. In other words, the tremendous volume of public financing effected during 1919 has simply made up for the curtailment brought about in 1918, through the agency of the Capital Issues Committee, as a war measure.

With some reports missing for the last few months of 1919, here is the record of state and municipal bond flotations for the last 10 years, as compiled from reports to the Daily Bond Buyer:

1919	$748,205,783
1918	262,818,844
1917	444,932,848
1916	497,403,751
1915	492,590,441
1914	445,905,510
1913	408,477,702
1912	399,046,083
1911	452,113,721
1910	324,360,955

SCIENCE OF MANAGEMENT

Application in Civil Engineering and Construction Fields

The term Science of Management was coined by the editor of Engineering and Contracting and first used in "Cost Analysis Engineering" (1908) and explained more fully in "Cost Keeping and Management Engineering" (1909). The last named book, which contains ten laws of management and many subsidiary principles, was the first book on the science of management. In the columns of this journal many additional laws, principles and detail methods of management have been published. This section, which appears weekly, may be regarded as a serial sequel to the two books above named.

The Rise and Fall of An Industrial Democracy

When trials of new institutions prove unsatisfactory little or no reference is usually made thereto. That which was heralded as an achievement passes quietly into oblivion, and those who had no direct relations with it may not even notice its disappearance. Recently we have heard much of the successes of "Industrial Democracy"; and unless we gave the matter careful thought, we may not have realized that it has had its failures too. Of particular interest, therefore, both in subject matter and as an unusual confession of failure, is a brief account of the experience of the "Kabo Corset Co." of Chicago, published under the title, "Why Industrial Democracy Failed," in 100% Magazine for October, 1919. The article is by Mr. Frederick H. Mill, personal councillor for the company named.

We do not offer this as evidence of the failure of the entire industrial democracy idea, but merely as another piece of data for consideration with the rest which we have or may acquire

Not the least interesting part of Mr. Mills' article is the last section, in which he outlines the plan now in operation—a plan marked decidedly by the spirit of progress. The article follows in full:

Our Industrial Democracy was organized in the summer of 1916. Under the plan we had a Chief Executive and a Cabinet made up of members of the staff. We had a Senate made up of foreladies, foremen and instructors, and a House of Representatives with the members elected by the employes from among their own number.

All matters relating to factory management, production, working conditions, wages, etc., were taken up in the House or Senate. The Chief Executive had the veto power.

Under the personal leadership of the organizer, a man of dominant personality and dynamic power, the employes became enthusiastic. Production increased 100 per cent, working conditions were bettered, labor troubles did not exist. When the management held back, powers of persuasion were brought to bear and the proposed changes were made.

Working hours per day were decreased from 10 hours to 9 hours, then to 8¾ hours, and still production increased. The Industrial Democracy was a great success, but after five months the time came when its leader went away!

How Things Went Wrong.—Everything went along all right for a few months, but the employes were not quite so enthusiastic. Elected leaders were only fellow employes, fellow employes were familiar, and—"Familiarity breeds contempt."

Then the management began to use the veto power, for instance against the installation of certain flat bonus plans in use in other plants, and there was no leader to intervene; when the management tried to explain, there was no leader in whom to place confidence.

To the employe (60 per cent foreign), the management was the management, something to be suspicious of. Wasn't it a management of high executives; wasn't it a management that really had the final decision in everything? And the elected leaders, who were they but mere employes like themselves, working at time or piece work rates?

To be sure the employes had social gatherings, meetings, parties, dances, etc., in which the executives took part. When the employe was sick often a friendly message or a sum of money found its way into the worker's home, sent by a sympathetic management which, like the factory worker, did not understand that there is never equality in anything.

If the general manager had had the time (which he did not have) to go into the homes of the employes, and the inclination and desire (which he did not have and could never attain) to adopt the habits and customs of the employes, he might have understood and looked at things from their viewpoint; had the employe broken away from his environment which he had no desire to do) and possessed himself of the intellectuality of the manager (which he in most cases lacks the inclination and ability to do) he would no doubt have looked at things through the eyes of the management.

And because of this inequality which exists in everything and must always exist, the sympathetic acts of the management and the timid seeming indifference on the part of the employe was misunderstood. It hurt!

Production began to fall off. Piece workers began to resent acting as representatives while time workers took advantage of the absence of instructors and foreladies from departments during Senate meetings to have a good time. Discipline disappeared.

In the meantime the cost of living increased. Individual employes declined to take the matter up with representatives because of the slow action of the Congress. The management decided that the wage question was one that should be dealt with as it saw fit.

The representatives and Senate members immediately decided among themselves that the meetings were only an opportunity to get an hour of rest. Operators in the factory followed the example set by their immediate superior. The employes became dissatisfied and began to make demands of the management through their representatives.

Senate members made demands indirctly through the representatives, using influence as department heads and hiding themselves from the management behind the persons of the representatives who by threats and persuasions they forced to suggest and demand changes which the Senate members thought would benefit them individually.

The Industrial Democracy went out of existence in April, 1919, when the House members moved that a portion of the management be removed and that the salaries paid that management be distributed among the employes.

As an army without a leader becomes an irresponsible mob, so the Industrial Democracy without adequate education and leaders who understood became a labor organization of a radical nature.

A forest fire destroys. A back fire may check the forest fire—but remember—it also destroys! There can be no equality. Labor is honest. Therefore do not try to deceive labor and persuade it to do something which it is unfitted to do. Labor does not want to manage. It wants only justice.

The solution of industrial problems lies in a scientific management recognizing the relative requirements and deserts of both capital and labor.

The Merit Plan.—After much investigation of labor plans based on the principles of scientific management we finally decided to adopt a plan which might be called a merit plan or task and bonus plan.

Under this plan every employe is paid a fixed weekly salary. Absences and holidays make no difference in the size of the weekly pay. Therefore labor knows what to expect and can plan in advance.

Employes are classified according to production, ability, skill, length of service, punctuality and attendance. Each classification calls for a certain salary which is guaranteed the employes.

Production tasks for each classification are set by scientific methods, and an employe may by maintaining the task of a higher classification for one month be given the higher classification. Extra points are awarded for additional work done, helpful suggestions made and perfect punctuality and attendance.

Discounts are given for breaking of rules, falling below average daily task for one month, absence, tardiness, etc. Rules and regulations are all made by employes themselves. Labor is fair.

Discounts are entered on a discount form and presented to the employe by an executive. If the employe accepts the discounts without question as just, he signs the discount form and returns it to the executive who then has the discounts entered against the employe.

However, should the employe feel that the discounts are imposed unfairly he is required to sign the form in the place marked unfair, and send it to the trial board, made up of disinterested individuals outside the factory, who receive no remuneration for their services as such.

Should the trial board find that the discounts were imposed unfairly the employe is awarded extra credits for his trouble while the executive who imposed the discounts is penalized by a number of discounts equal in number to those he imposed unfairly.

By obtaining sufficient credits an employe may reach a grade which entitles him to a quarterly dividend on a sum equal to one, two, three, four or five years' salary, depending upon the grade reached. This dividend is based upon the dividends paid on the company's common stock and is guaranteed to be not less than 3 per cent annually.

A sinking fund is provided to take care of the guaranteed dividend during periods of business depression.

In cases where it is absolutely necessary to cut down the working force, employes will be laid off according to classification.

To become a regular employe and participate in all privileges of the Tasks and Bonus Plan, a worker is required to spend a two-months period in the factory on probation.

The plan is flexible enough for any industry and fair to all. It gives nothing which is not earned and under it nothing is received which is not paid for.

Under this plan a man receives a man's due and a shirker receives a shirker's due. It is not based on the equality of man. It is based on relative achievement and a square deal.

Engineers Well Represented on City Planning Commission

It will afford gratification to members of the profession to learn that of the 10 members of the newly organized city planning commission of Tacoma, Wash., whose first meeting was held on Feb. 26, three are engineers, and that from these three were chosen both the president and secretary of the new body. The professions are further represented by one architect and three lawyers; while each of the other three members was chosen for some special qualification.

The personnel of the commission is as follows: Members ex-officio, Mayor C. M. Riddell (in private life a lawyer); City Attorney V. E. Harmon; City Engineer James C. Mauley. Members appointed by the mayor: Mrs. John Goldsberg, specialist in housing and sanitation; Mrs. E. L. Carlsen, worker in various phases of civic betterment; James A. Hays, member of Metropolitan Park Commission; Roland E. Borhek, architect; John Cecil Black, civil engineer; W. C. Raleigh, former city engineer, now a member of one of the city's largest real estate firms; George O. Sivasey, attorney.

Recommendations of the local chapters of the American Association of Engineers and the American Society of Architects were asked for and followed in the appointment of members of those professions.

At the commission's first meeting Mr. Raleigh was elected president, Mrs. Carlsen, vice president, and Mr. Black secretary. It is expected that the first important work will be in connection with a comprehensive zoning of the city for use, building height and area.

The commission was established under a special ordinance recently passed, which provided in considerable detail for its organization and functions. The latter are entirely advisory, but it is expected that the next regular session of the State Legislature will pass enabling laws giving much greater powers to cities in these matters, and permitting of stronger commissions.

Piece Rate Versus Time Schedule

In the issue of "Industrial Management" for October, 1919, Mr. Leon Blog presents under the title "A Defense of the Piece Rate Method of Wage Payment," an interesting comparison of payments to "the superior man" under the piece rate and time schedule methods respectively. Mr. Blog's argument is in reply to a paper ("My Objections to the Piece Rate Method of Wage Payment") by Mr. Harrington Emerson which appeared in the June and July numbers of "Industrial Management." The main contention of Mr. Blog is that the objections raised to piece rates are equally applicable to time schedule rates, while the latter are much more complicated and less satisfactory in other ways than are the former. The conclusions as stated are:

1. There are no practical, administrative or phychological objections to any piece rate system in vogue that cannot be removed by a right-minded management. Where they exist at all the piece rate system is not thoroughly understood and a house-cleaning is necessary.

2. The piece rate method of wage payment:

(a) Is fairest to worker and management.
(b) Rewards the worker the most for superior ability.
(c) Is easiest to modify in a labor trouble emergency.
(d) Most certainly insures balanced production.
(e) Is scientific, unarbitrary and hence sound.

3. The time schedule method of wage payment is based on a novel idea for which too much is hoped. As he has done with all other systems of production coaxers, the worker will soon detect this one if it be installed, and it will also become a red rag whether deservedly or not. Its bonus nature will bring on all the troubles incidental to bonus systems and a speedy return to a scientifically established piece rate method of wage payment will be the remedy.

The comparison follows:

Let us consider the walking problem:

Assume that Mr. Emerson's rule that a good standard performance is one-half of the maximum of which a well-trained person is capable, is correct. It it be correct, a time study taken on, say, 50 men will show that the average man can walk 24 miles in 8 hours. The basis of a piece work rate on an operation is the performance of the average man on that operation. From the table on page 18, July issue, Mr. Emerson is willing to pay this average man for walking 24 miles in 8 hours, $3.456.*

We get:

Man.	Miles.	Time, hours.	Rate per hour miles.	Pay for 8 hours.	Price per mile.	Pay per hour.
Average	24	8	3	$3.456	$0.144	$0.432

Let a superior man do it in 6 hours and assume he will walk the remaining 2 hours. His rate per hour in miles is 4. He walks 2 times 4 or 8 extra miles, and computing his pay for 8 hours we get:

24 miles at $0.144	$3.456
8 miles at 0.144	1.152
Pay for 8 hours	$4.608
Pay each of 8 hours	0.576

Consider the illustration page 18, first paragraph, second column, July issue.

"If I am expected to walk 24 miles in 8 hours and I actually walk the distance in 6 hours, what pay ought I to have?"

Regular hourly rate for 6 hours	$2.16
20 per cent because I have attained standard	.432
Pay for 2 hours saved at 0.36 ct.	.720
	$3.312
Assume this superior 6-hour man walked the two hours saved.	
8 miles at 0.144 ct	1.152
Pay for 8 hours	$4.464
Pay each of 8 hours	0.558

This is $0.018 per hour less than under the piece rate method. In 8 hours this amounts to $0.144.

Under which system would the reader prefer to walk, if in both cases he had to walk for 8 hours?

To make $0.576 per hour the reader would have to walk

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*This is calculated as 8 hours at $0.36 — $2.88 plus 20 per cent for having attained the standard — $0.576 — Total $3.456.—Editor E. & C.

32 miles. To make $0.552 per hour he would have to walk 24 miles and if he chose not to loaf the two hours saved, he would have to walk 32 instead of 24 and still make only $0.558 or 6 mills an hour more. In 8 hours, this would amount to only 6 times 8 or 48 mills, almost 5 cents per day more. What manager honestly thinks a walker would walk the extra 8 miles for 5 cents?

In brief, the walker gets the greatest net return by walking under the piece rate method; the management actually gets greater production when the greatest net return has been earned. Hence the piece rate method of payment is fairest to both worker and management.

Reward According to Ability.—Referring to the above problem:

	Piece rate method.	Time schedule method.
Average man rate per hour.......	$\frac{\$3.456}{8}$ is \$0.432	$\frac{\$3.456}{8}$ is \$0.432
Superior man per hour....	$\frac{4.608}{8}$ is 0.576	$\frac{4.464}{8}$ is 0.558
Difference per hour	\$0.144	\$0.126

That is, in the piece rate method of wage payment the superior man's rate per hour exceeds that of the superior man in the time schedule method by $0.018. Again the piece rate system is superior.

Simplicity of Modification in Times of Labor Stress.—Suppose one hour before closing time in a plant in which there are 5,000 different operations, the management hears that there is to be a walkout. Each piece rate has been based upon time study and for each operation a definite minimum earning per hour has been promised the workers on that operation when they were hired in. The piece rate was figured as follows:

Operation: Drilling $\frac{3}{8}$-in. holes in $1\frac{1}{2}$-in. ash, single drill.
Standard time: Per 100 holes, 10 minutes (includes delays).
Hiring rate per hour: $0.60.
Piece rate .... $\frac{10 \times \$0.60}{60}$ = $0.10 per 100 holes.

To avert the walkout, the management decides to pay the men on this operation at the rate of $.66 per hour.

The new rate is.... $\frac{10 \times \$0.66}{60}$ = $0.11 per 100 holes.

The change of rate requires only a simple multiplication. In a few hours, the 5,000 rates could be revised and the new piece rates posted before the men came to work in the morning.

To change rates in the time schedule method requires for each operation the calculation of a table such as is shown page 18, column 1, July issue. Ten calculations are there shown.

The piece rate method is, then, the easier to revise.

Which Method Is More Scientific? A good time study man goes out into the shop open-mindedly, impartially and judicially to determine the standard time of an operation in order to set a piece rate. He uses a stop-watch, makes careful observations on each detail of the operation, noting constants and variables. He sets the time on the average man after he has determined who he is by time study. In the office, he eliminates the variables and gives the operator credit for delays beyond his control. In all this, there is very little judgment. Facts are the basis of the determination of the standard time. To have facts is to possess knowledge and to have such knowledge, is to be scientific.

Is the time schedule method scientific? The writer believes not. True, the "maximum performance" of the well-trained person can be established as carefully as the standard time for the average man. Then either Mr. Emerson's rule, "A good standard performance is one-half the maximum performance of which a well-trained person is capable" has to be applied, or we have to determine by study for each operation what "a good standard of performance" is. If we blindly use the rule we are arbitrary and so unscientific. If we determine the "good standard" by study, we are really making two time studies per operation. How many readers of experience would want to use the rule? In a small plant, two studies could be managed, but in a large progressive one where operations are continually changing, the rates could not be kept up to date with a reasonable staff. Another arbitrary figure must be chosen to represent a qualification performance. This is the minimum amount to be done in a specified time by a man expecting to qualify for the job. In the walking problem this is 16 miles in 8 hours. Why 16 and not 14 or 20? Another arbitrary figure is the percentage by which the pay for qualification performance must be increased to pay for a superior performance. Qualification pay is $0.36 per hour for 8 hours, or $2.88. The arbitrary figure is 20 per cent, which applied to $2.88 gives a pay of $3.456 for standard performance. To get the pays for performances between qualification and standard, pay at qualification would be increased by the percentage between 0 and 20 corresponding to the increase in efficiency above qualification. Why was 20 per cent chosen?

Fundamentals of Business Success

Engineering and Contracting makes an apology for the frequency with which it prints matter of this character, for it knows that any one who has made a start—however small—on the road to real success, appreciates. First, that its requirements are manifold. Second, that beyond the fundamental of all success, there are many other essentials which vary with the individual, the personality, the environment, the business, and with other factors. Third, that through a study of the reason of other men's success, it is possible to adopt many of these essentials into one's own life and practice with vastly less expenditure of effort and of time than would be needed for their acquisition by personal experience.

Mr. Houston Lowe is the successful head of a successful business—that of Lowe Brothers Co., of Dayton, O., manufacturers of paints, varnishes, etc.—and in an interview published in a recent number of The American Magazine, under the heading, "Three Things Learned from Fifty Years in One Business," he presents so many valuable ideas that we quote extensively from the article:

Why College Men Usually Make Poor Salesmen.—"Different kinds of training fit a man for different kinds of work. For example, college men are valuable in certain positions; but I have found in my own experience that they seldom make good salesmen.

"It seems to me the reason they do not succeed in that line is that they have what may be described, for want of a better word, as too much 'humility.' That sounds startling, but what I mean is this: Their training has made them too much inclined to feel that there are several sides to any proposition; probably because of this they are inclined to hold back when it comes to selling anything.

"The good salesman does not walk all around a proposition and hesitate and give way. He has one idea, an enthusiastic belief in what he is selling and, based on that belief, a conviction that his customer ought to buy it But the college man has been trained to allow other men to decide their affairs for themselves. That is part of the 'ethics' of college life. So when he comes to selling goods he is likely to go on letting the other man—in this case his customer—decide for himself. And as it is the instinct of most customers to begin by saying they don't want a thing, the student accepts that refusal as final."

Selling Paint and Ideas.—In an address to salesmen, Mr. Lowe said:

"The big thought I should like you to carry away from here is this: First, it is your business to sell. That is understood. But what is it you are to sell? Why, you are to sell paints, varnishes, and so on. Yes, of course. But these things are merely instruments. The fundamental thing is that you are to sell ideas; ideas of beauty, of health, of economy, of prosperity, of service."

In the interview in the American is the following:

"As I said before, this belief that every business is built around certain ideals should be a fundamental principle of a man's business creed. This is what I mean when I talk to our salesmen about 'selling ideas through the medium of paint.'

"I tell them they must not think merely of selling so many cases of paint or of varnish. They must think what this paint or varnish is to accomplish! Because it improves the appearance of a home, or an office, or a building, they must sell their prospective customer the idea that paint means Beauty. Because cleanliness is sanitary, they must sell the idea that paint means Health; because it preserves surfaces, they must sell the idea that paint means Economy. Cheerfulness, brightness, color—these make a pleasing environment; therefore paint may actually mean added Happiness. People are attracted to a store, or a theater, or even to a church, if it is well painted and artistically decorated; and for that reason paint means Prosperity."

On Picking Men.—Mr. Lowe makes some forceful statements regarding the picking of men to work under and with him:

"The quality I look for most keenly from my very first encounter with a man—or with a boy or a girl either—is sincerity," says Mr. Lowe. "I like a man who looks me in the eye, and who does it because it is the natural expression of a direct and honest personality, not a trick he has tried to acquire because he thought it was a good one.

"You can tell the difference. The eyes themselves may be held steady; but there is something in them that wavers and shifts, if the act is not natural to the man.

"One must always look for character in choosing men, for there are two things which count in a healthy man's work: character and knowledge. He can, to a certain extent, acquire both, but knowledge is gained more easily than character.

"One of my old classmates in New Haven, Professor A. J. DuBois, once defined character as 'right action become habitual through the voluntary exercise of the will.' In that sense, character, good or bad, is formed by everyone. And I like a man who seems to be forming his character by making 'the right action habitual.'

"Another thing about choosing men is this: Pick at least some men who are the complements of your own temperament. For instance, I am inclined at times to be over-enthusiastic. My wife has been a wonderful help to me in that respect. Her calm judgment has often served as a necessary brake on my impetuosity. I am sure that many men will say they owe much to the fact that their wives have supplied the quality they themselves lacked—calmness, if they were too hot-headed; optimism, if they were pessimistic; humanism, if they were too much taken up with hard materialistic aims.

"For the same reason, a business organization should be a many-sided one. If an executive is very conservative, and chooses only conservative men to work with him, the business will suffer, because it will lack the eager enthusiasm which a few alert and progressive men would supply.

"If an executive who is impulsive and very optimistic surrounds himself with other men who are as impulsive as he is, there is danger of their pace becoming too rapid, their decisions too hasty. They need a few cautious conservatives, men who weigh things carefully and who even instinctively look for trouble. An organization, to be efficient, should be well rounded and well balanced."

Character and Ideals.—"I do not look upon this paint business as altogether a money-making business. It is more than that. It should be a man-making business. And not a one-man business, either. . . . It cannot be too often repeated that business is done now, and should always be done, on the co-operative principle. 'No man liveth to himself alone.' We must serve others if we expect to be served.

"As employers, our first aim was to secure workmen of character and ability. Then we tried to keep their interest in their work, first, by giving them steady employment, even when it would have been to our immediate advantage to let them go temporarily; second, by giving them an equitable wage; third, by calling for reasonable hours of labor; and, fourth, by trying to provide comfortable and attractive surroundings.

"I consider those four things essential to the success of any business concern. And in addition, we tried to interest our workers in the basic principles involved in making our product. That is, we tried to treat our men as intelligent human beings, tried to make them think.

"I might better say that we gave them the opportunity to think; for I believe most men are glad to be something more than mere machines. . . .

"Here is another important thing: A business is always built around certain ideals. They may be good ones or bad ones; but they are always there. And every idea in that business must bow to those ideals.

"If the ideal around which a business is being built up is one of mere selfish money-grabbing, the ideas used in manufacturing and selling will surely bow to this ideal. You will find that business honeycombed with ideas of cheap labor, cheap production, swollen profits—all of them ideas for furthering selfish gain.

"On the other hand, if the central ideals are faith, happiness, and service, the ideas permeating that business must and inevitably will be those of honesty, integrity, confidence, quality, and customers who are well served and satisfied." . . .

"If I were an employe, I should ask myself what were the ideals of the firm for which I was working, and whether I wanted to make them my ideals, too.

"A man may be upright and honorable, fair to his employes, honest in all his dealings, lofty in his ideals of service, and yet fail to succeed in his work or his business. Character alone will not keep the sheriff from his door.

"When it comes to building an enduring edifice on that foundation of character the thing a man needs in addition is—knowledge. He must know his work, whatever it is. By just so much as he increases his knowledge of it, that which he builds becomes broader and bigger and more substantial."

Study Broadly.—Mr. Lowe has much to say of the importance of a minute knowledge of one's business specialty, and he permits of no false pride in the acquisition of that knowledge.. With him, the study of his business is a lifelong occupation.

"In studying the problems of my business I have talked with all kinds of men and I have learned much from some who might seem the least promising sources. I stop to gossip with a painter at work, and learn from him something that he has learned from actual experience. I find that he has some way of thinning the paint, or a trick of applying it, something that he has worked out for himself; and from it I get a hint I can make use of.

"We have heard the statement often enough that 'no one man has a monopoly of ideas,' but we don't act on that theory as we should. We do not systematically search for the ideas other men may have. And in the case of employes, we do not always encourage them to have ideas."

But he sounds a note less usual among business men when he pleads also for that broader study which we call culture.

"If you cannot teach, you cannot succeed. The more you try to teach others, the more you will teach yourselves.

"I believe this is sound advice. A man who thinks he is expected to teach others will try to get hold of something worth passing on to them.

"I believe, too, in the value of study outside the apparent scope of your business. It is a mistake to think there is a sort of wall around your business, and that the things beyond that boundary have no connection with your work. Any man who reads widely realizes that this limitation does not exist. Out of what is called 'general reading' there very often come unexpected ideas and suggestions of definite practical value to him.

"But even more important is the effect which such reading and study have on his mind and character. The man who cannot learn from history, from biography, from the best thoughts of the best minds, things that will help him in his daily life, must be—but then, there can be no such man! So why try to describe him? Men have only to make the experiment to be convinced that it is worth while.

"In my own experience certain books have had a particularly strong influence on me. They are Jevon's work on the 'Principles of Science,' and Karl Pearson's 'Grammar of Science.'

"One reason why Jevons and Pearson helped me was because they showed me that certain of the problems I had been trying to solve were insoluble. I had been working and studying over them, and was vexed and discouraged over my failure to find a way of mastering them. When I found that there was no such way, that better men than I was in that line had proved them incapable of solution, a mental burden was got rid of.

"These two books, of course, were helpful to me technically. But books in general have not only interested me, but helped me to humanize my business. Why should a man make his work a mere routine affair of materialistic facts and figures? I am constantly finding things in my general reading that give flavor and color to my thoughts about business.

"If it seems absurd to you to link up philosophy and even poetry with your 'sordid' business affairs, you are missing a great deal of pleasure and of profit. For if you are content to have your work a sordid thing, your returns from it will be only sordid; and even those will be less, I believe, than they might be if another spirit went into the making of them.

Decisive Action Eliminates Worry.—"Some years ago I read a book, Horace Fletcher's 'Menticulture,' which helped me a great deal. In it he discussed the necessity of getting rid of worry and anger. I was telling someone about it a long time afterward and casually announced that I followed the book's injunction and 'got rid of worry.' Not unnaturally, my friend demanded with some impatience:

"'But how?'

"'Well,' I said, 'I got rid of worry by getting rid of the men who were causing the worry. I had some associates at that time who did not inspire me with either confidence or liking. On the contrary, I distrusted them and was irritated by them. Yet I had felt that in certain ways they were necessary to the business and that I could not risk letting them go.

"'But when I got to thinking about worry and realized that those men were at the bottom of nine-tenths of my worry, I decided that my peace of mind was as necessary to the business as they possibly could be—and it was vastly more necessary to me. So I got rid of the men who were a thorn in my side, filled their places with those I could trust and like, and it proved to be as good a thing for the business as it was for me.'"

News Letter

St. Louis Items

The L. J. Smith Construction Co. of Kansas City was awarded another big trestle filling job on the White River branch of the Missouri Pacific R. R.

A. L. Cook, Ottawa, Kans., can use several small team outfits on the M., K. & T. R. R. between Sedalia and Nevada, Mo.

The Frisco Railroad plans to spend within the next few months more than $1,000,000 in improving its lines within a radius of 200 miles of St. Louis. This work is to begin with the double tracking of the system between Pacific and Eureka, Mo., a distance of seven miles, costing $435,000, and also between Lebanon and Sleeper, Mo., nearly eight miles, costing $225,000. It is expected the work will begin within 30 days. The laying of a double track over this portion of the lines is only preliminary to similar work to be done later on other parts of the system, but it is unlikely that any great amount of this will be done this year. The improvements contemplated for this summer, however, are expected to greatly expedite traffic to and from St. Louis over the Frisco lines.

Mulvill Bros. of Alton, Ill., have five miles of second track work between Bierd and Nilwood, Ill., on the C. & A. R. R. to sublet.

John McInerney, after spending 18 months in France, is back in the contracting business again. Has a season's job with the Studebaker Motor Co. grading property in South Bend, Ind. His address is 129 St. Joseph street.

Bids for the construction of the William Stix School, Euclid and Duncan avenues, St. Louis, submitted to the building committee of the Board of Education, exceeded the estimated cost of the work by $32,309. The lowest bid received was $437,809, while the estimated cost of the work was $405,500. The committee submitted its recommendations to the board April 13. The estimate for the building was $300,000, the lowest bid for this part of the work alone being $312,000. Bids for various other features of the construction which were in excess of the estimates were: Mill work, $20,000; plumbing, sewer and gas, $21,721; heating and ventilating, $62,880; electric wiring, $13,360.

M. Federer, 4100 Gravois avenue, St. Louis, Mo., is grading real estate in the southwest part of the city. Federer says he can use a few more wheelers and teams on this job.

J. B. McGarry, 40 Burns avenue, Akron, O., writes us that he wants to hire or rent a 20-team outfit by the day at that place. Has between four and six months' work. Will hire teams with or without drivers.

The Board of Local Improvements of Alton, Ill., closed a contract with J. G. Melluisch for the engineering work required in the building of the Piasa sewer. He will do the work for 5 per cent of the cost of the job. The cost probably will be more than $300,000.

George E. Dutton, 703½ Louisiana avenue, Shreveport, La., has 100,000 yards of drag line work two miles outside of Shreveport to sublet. States he can pay a good price for it and wants work started immediately.

Herring & Shellhouse, engineers, Forest City, Ark., can use a 7 or 8-team outfit to do force account work on highway, filling washouts and shaping roadbed for gravel.

Robert Oliver, 4430 Chouteau avenue, St. Louis, Mo., has a 10-team outfit that he wants to place onto a job in this part of the country

W. F. Woodruff, Bedford, Ind., reports his 7-team outfit idle at that place.

Columbus S. Jones has started on a new job of station work on the M., K. & T. R. R. near Boonville, Mo.

A. Waddell has moved his outfit to Walker, Mo., where he is doing some bank widening for the M., K. & T. R. R. Waddell can use a small team outfit or two at this place.

J. B. Fields has subbed a job of bank widening on the M., K. & T. R. R. from A. L. Cook.

Contractors when in want of work or labor for their outfits write Koenig Labor Agency, 612 Walnut street, St. Louis, Mo.; 513 Delaware street, Kansas City, Mo., or 509 S. Thirteenth street, Omaha, Neb.

The Board of Public Service, Room 208, New City Hall building, St. Louis, Mo., is asking for bids for improving Kingshighway Northeast from Euclid to West Florissant avenues, also for reconstructing Biddle street from 14th street to 17th street; also reconstructing Locust street between 14th street and Jefferson avenue. Plans, specifications, form of contract and other information can be had at the office of the president of the Board of Public Service, City Hall building, St. Louis.

P. J. Hannan returned from Fort Smith, Ark. He is completing the track laying and ballasting on the Fort Smith, Sabiuca & Rock Island R. R. Expects to turn this road over to the company in a few weeks.

A. B. Koenig.

Personals

Alex. Deleglise has been elected city engineer of Antigo, Wis.

Frank Kimball has been appointed city engineer of Albuquerque, N. Mex.

Stacy S. Rumpeltin has been reappointed village engineer of Johnson City, N. Y.

Jere F. Harrison has been appointed superintendent of the light and water department of Smithfield, N. C.

J. H. Rayburn has resigned as secretary of the Chamber of Commerce of Scottsbluff, Neb., and will become city manager of Chadron, Neb., at a salary of $5,000 a year.

George Grupe has resigned as superintendent of waterworks of Cleburne, Tex., to accept the position of city manager of Brownsville, Tex., at a salary of $5,000 per year.

Maj. John A. Griffin, a member of the Los Angeles city engineer's staff for the past 12 years, has been appointed city engineer, succeeding A. C. Hansen, who died recently.

Paul W. Doerr has resigned as assistant superintendent of the city water and light plant of Lincoln, Neb., to accept the position of plant superintendent at the Western Potash Works, Antioch, Neb.

Major General William C. Gorgas, former surgeon general of the United States Army, has accepted a five-year contract with the Peruvian Government to direct an extensive sanitation program at Lima, Peru.

Fred O. Eichelberger, city civil engineer of Dayton, O., has been appointed director of public service, succeeding H. P. Martin, formerly of Cincinnati, who resigned to accept a position with a Dayton manufacturing company.

George M. Shepard has recently been made associate with Louis P. Wolff, consulting engineer of St. Paul, Minn., in his practice of municipal and sanitary engineering. Previous to discharge from the Army in January, 1919, Mr. Shepard was captain of engineers on duty with the 3rd U. S. Engineers as Schofield Barracks, Hawaii.

Industrial Notes

The Taber Pump Co., Buffalo, N. Y., is now represented in Chicago by G. T. Shushan, 410 Cunard Bldg.

The Mitchell-Rand Mfg. Co., New York, has taken over the business of the Universal Compound Co. and will manufacture and sell the products of the latter organization under the M-R trademark. These specialties include Universal damp-proof compound. Universal water-proof plastic, etc.

D. C. Reeves has recently joined the Holt Manufacturing Co., Inc., of Peoria, Ill., as domestic sales manager. Previous to 1913 Mr. Reeves was a member of the firm of Hall Bros. & Reeves, distributors of motor cars and motor trucks. In 1913 his firm took on the tractor business. In 1916 Mr. Reeves joined the J. I. Case Plow Works as tractor sales manager of the Kansas City branch. In 1918 he was transferred to the parent office at Racine as tractor sales manager.

M. C. W. Boyd has resigned from active management with the Heltzel Steel Form & Iron Co., Warren, O., as manager of sales. He, however, retains his official connection with the company and his financial interests in it. Hereafter he will be actively engaged as general manager and treasurer of the Good Roads Corporation of Kansas City, Mo., manufacturers of high pressure atomizing road oilers, power flushers and power spreaders of tar and bituminous material. W. J. Savage has been appointed director of sales in charge of the steel form department of the Heltzel Steel Form & Iron Co., and E. V. Ford will be in charge of the sale of Parrish templates and finishing machines.

John A. Kienle, formerly sales manager of the Electric Bleaching Gas Co., has been appointed general manager of sales of The Mathieson Alkali Works, Inc. This change was brought about by the severing of relations between the Mathieson Alkali Works, Inc., and its former sales agents, the Arnold, Hoffman & Co., Inc. It is the intention of the Mathieson Alkali Works, Inc., to sell all of its products (caustic soda, soda ash, Virginia soda, bicarbonate of soda, bleaching powder, liquid chlorine, chlorine solvents, etc.), direct to the consumer instead of through sales agents. Mr. Kienle has been placed in charge of the development of a complete sales organization. E. E. Routh, formerly manager of bicarbonate sales, has been appointed as assistant to Mr. Kienle.

The Link-Belt Co., whose general offices are in Chicago, is carrying out an extensive program of expansion at its works in Chicago, Philadelphia, Indianapolis, Seattle and Toronto, Can. New manufacturing facilities have been added to the several plants and the personnel of both factories and sales offices has been increased. Two new furnaces—the seventh and eighth—have been added to the chain works at Indianapolis in the last few months. Announcement of the purchase by the Link-Belt Company of the Fairmount Foundry at Philadelphia was made a few days ago by Charles Pie, presidenzt of the Link-Belt Co. This deal involved several hundred thousand dollars. The foundry will be used as an adjunct to the eastern works at Philadelphia, supplying this plant with gray iron castings. A new administration building is under construction at the Philadelphia works, and plans are being made to erect another such building at the Chicago works, to make room for large engineering, sales, drafting and clerical staffs. The shops at Toronto and Seattle are being expanded. In the Chicago works foundry a conveying system is being installed to speed up output. A new warehouse is under construction at Seattle. The Toronto shops and offices will shortly occupy new quarters there. A. C. Johnston, formerly chief engineer of the Chicago works, has been elected a vice-president of the Link-Belt Co. and resident general manager of the Chicago works. He succeeded Prentiss L. Coonley, who resigned to devote his time to the presidency of the Isko Manufacturing Co.

Railways and Excavation Monthly Issue

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Roads and Streets—1st Wednesday
(a) Roads (c) Street Cleaning
(b) Streets (d) Municipal Miscellanies
(e) Management and Office System

Waterworks and Hydraulics—2nd Wednesday
(a) Waterworks (c) Irrigation and Drainage
(b) Sewers and Sanitation (d) Power and Pumping
(e) Management and Office System

Railways and Excavation—3rd Wednesday
(a) Excavation (c) Quarries and Pits
(b) Management and Office System (d) Steam Railways, Construction and Maintenance
(e) Electric Railway Construction and Maintenance

Buildings and Structures—4th Wednesday
(a) Buildings (d) Miscellaneous Structures
(b) Bridges (e) Properties of Materials
(c) Harbor Structures (f) Management and Office System

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What Is Economics?

An editorial article under the above given title appeared in our March 3 issue. In our issue of March 24, C. C. Williams, Professor of Civil Engineering, University of Kansas, said:

> Your editorial says, "It seems to us that a serious mistake was made in defining economics in such a narrow manner as to make it synonymous with political economics." The committee (of the S. P. E. E.) made no attempt to define economics, but merely attempted to use it in the accepted sense and as the word should be interpreted in terms of college curricula. The International Dictionary, probably the most widely accepted authority on the meanings of words, give the following definition of economics: "The science that investigates the conditions and laws affecting the production, distribution and consumption of wealth, or the means of satisfying human desires; political economy." No other definition is recognized by the authors of that work. Examination of some two dozen standard texts on the subject reveals no appreciable divergence from this conception of the subject on the part of their authors, and an interrogation of several professors of economics yielded a similar result.
>
> It is the writer's opinion, therefore, that the situation is only confused by not recognizing an accepted definition of a term and failure to do so only provokes discussions in which opinions appear to differ when in fact they do not. After a fairly intimate canvass of the practice at various institutions, the committee found that practically every college in the country uses the term in the sense attributed to it by the dictionary and by the committee, including thereunder such matters as corporation finance, labor problems, accounting, banking, and other phases of commerce, and this fact alone would warrant the distinction made by the committee, since the report was to be interpreted in terms of college curricula.

Prof. Williams cites the definition of economics given in The International Dictionary, and adds that examination of "some two dozen standard texts on the subject" confirms the correctness of that definition. He does not give the names of the texts, but we infer that they are mostly text books on political economy. Our March 3 editorial was mainly an attack on the definitions of economics found in most modern text books on political economy, our claim being that specialists in political economy have no right to usurp a word that is commonly used in a much broader sense than they use it.

By all odds the greatest dictionary in the English language is the New English Dictionary, which is a British work based on the researches of the Philological Society. This great work is not yet completed but the 14 volumes thus far printed (A to S inclusive) contain more than twice as much matter as the corresponding volumes of our own largest dictionary, The Century Dictionary.

The New English Dictionary gives several definitions of Economics, from which we have selected the following:

> Economics: 2c. The science relating to the production and distribution of material wealth; sometimes used as equivalent to political economy, but more frequently with reference to practical and

28 Pages=40 pages

The 28 pages of articles in Engineering and Contracting contain as many words as 40 pages of the size and typography commonly used by other engineering periodicals. Ours is the same size of type and type-page as that of The Literary Digest—easily read, yet giving a large volume of reading matter per page. Our 28 pages of articles would fill 112 pages of the standard 6x9 in. text-book. It would take 10 such books of 580 pages each to hold all the articles printed each year in Engineering and Contracting, to say nothing of our weekly construction news.

specific applications. Sometimes qualified by an adjective prefixed, as in Rural Economics.

The Century Dictionary gives the following:

> Economics. 2. The science which treats of wealth, its production, distribution, etc., political economy. . . . . "Among minor alterations I may mention the substitution for the name of Political Economy of the single convenient term Economics." Jevons, Pol. Econ. (2d ed.), Pref.

Fortunately for our purpose, this quotation from Prof. Jevons disclosed the very object that we are opposing, namely, the desire on the part of political economists to make "political economy" and "economics" identical. That they were never regarded as identical prior to the time of Prof. W. Stanley Jevons is evident enough from reading the quotation from his book on Political Economy (1871). That Prof. Jevons and his followers have failed in his effort to narrow the meaning of economics is evident, from the fact that there are many kinds of economics, and books thereon, in existence today. The New English Dictionary cites "Rural Economics" as an example. The first chapter of Gillette's Handbook of Cost Data is entitled "Principles of Engineering Economics."

Prof. J. C. Fish is author of a book on "Engineering Economics."

In the introduction to his Lectures on Business Engineering, Prof. Humphreys mentions the change of name of the "Department of Business Engineering" (Stevens Institute) to the "Department of Economics of Engineering."

If the term "economics" were identical in meaning with the term "political economics," obviously Prof. Humphreys and Prof. Fish would be using the word incorrectly, for there would be no such thing as engineering economics. The fact is, as we said March 3, that, aside from professors of political economy, most men refuse to use "economics" and "political economics" as perfect equivalents. Engineers certainly have never used the two terms as equivalents; but a committee of the Society for the Promotion of Engineering Education has undertaken to lead engineers to change their practice in this respect. The committee made the natural error of relying upon a dictionary definition and of following the practice that professors of political economy have been so diligent in promoting these last 40 or more years. But the committee will find it impracticable to get any considerable part of the engineering profession to give up an indispensable word.

Prof. Williams says that economics is a "word that has become almost as threadbare through indiscriminate use as did the word 'efficiency' a few years ago." But would he have us, therefore, abandon the correct uses of efficiency and economics because they have been misused? If so, we had better begin by abandoning the name engineering.

Prof. Williams says:

> Moreover, the committee were of the unanimous opinion that there is very little warrant in current usage for the application of the term economics to the details of a business transaction, or of shop administration, to the design of a structure for minimum cost, to the details of handling labor, etc., and therefore the distinction between "economics" as believed by the committee to be the common acceptation of the term, and "economy of design, construction and operation," which some engineers have rather loosely assumed to be included in the academic significance of the word, was made to clarify nomenclature.

The term economics is a very broad term—a term that embraces a great class of data and methods—and it is futile for any committee to try to narrow it. What the committee seems to regard as a "loose" use of the term economics, we would regard merely as a broad use a use that the word has had ever since it ceased to mean merely "household management."

Prof. Williams says:

> Moreover, as pointed out by the committee, there seems to be so little in common between the theoretical economics as taught in collegiate departments under that caption and the extraneous matters which your editorial apparently would include in the scope of the term, that no advantage is to be gained by grouping them intimately together. These latter subjects are generally taught more or less adequately in connection with engineering courses but are not labeled "economics."

This argument might with equal propriety be used against any broad subject, engineering for example. There are a great many engineering subjects that have no more in common than have political economics and engineering economics. What is there in common between mechanical drafting and gunnery; between surveying and automobile design; between railway location and the dam design? Nothing, except the fact that they all fall within the scope of the engineer. Similarly, we find there is nothing in common between the subject of railway valuation (an engineering economic subject) and the relation of money to price levels (a political and business economic subject)? Nothing except the fact that they both fall within the scope of the economist. But that "exception" suffices. It is the thing that binds them together under one broad class.

Finally, let us add that one of the defects in many engineering courses today is the lack of a special course in economics. It does not suffice to teach the principles of economics merely as incidents in the teaching of bridge design, railway location, etc. Economics should be taught as a broad subject of which bridge design, railway location, etc., are merely branches.

Is Any Dictionary an "Authority" on the Meaning of Words?

When dispute arises as to the meaning of a word it is but natural that the disputants should turn to a dictionary. But how often do we stop to consider the fact that dictionaries are not the final authorities as to the significance of terms? "Dictionaries are word catalogs," and like any other catalog their statements are open to question. That the compilers of dictionaries recognize this fact is shown by the frequency with which they quote authorities. The men whom they quote are the authorities. The dictionary compilers are not.

Yet so ingrained are the habits acquired in youth that few of us are inclined to question a statement if "the dictionary says it's so." Richard Grant White is one of the few that have dared class the authors of dictionaries as being essentially ignorant not merely of the words that they compile but of their craft as compilers. Listen to the following from White's "Words and Their Use":

> Dictionaries are consulted chiefly for their definitions; and yet, upon this point, all our English dictionaries are more or less misleading and confusing. * * *
>
> Webster is not wholly responsible for the vicious system of definition upon which he labored with such conscientious thoroughness. This system originated with Dr. Johnson.
>
> Johnson's Dictionary was not only a work of great research—it was a work original in its design and its execution; and it is the model of all the great English dictionaries, except Richardson's, that have since been compiled. They are all founded upon Johnson's; but his was founded upon no other: it was the result of a critical examination of a range of English literature wider than had ever before been examined by one man for any purpose. It was almost inevitable that a dictionary made in such a manner should, with its great merits, have all the faults by which those merits are counterbalanced, and particularly this one of superfluous, over-subtle, misleading definitions. * * *
>
> I will not say, with him who yet remains the greatest philologist that has made the English language his peculiar study, Horne Looke, that Johnson's Dictionary is a disgrace to the English people, but there seems to be no reason for disputing Looke's judgment that Johnson's system was unscientific and vicious, and that a dictionary ought to be made of a very different kind from anything ever yet attempted anywhere. Now, all that has since been done in the making of English dictionaries is merely to build upon Johnson's foundation, and to work on his plan, with the increased materials and the larger knowledge provided by the development of the language and by the investigations of modern philology. * * *
>
> Between such dictionaries as Worcester's, the Imperial, and Webster's, in the last edition, there is not a choice worth the toss of a copper. In their labor-saving, thought-lulling convenience, as in their serious faults, their many and grave deficiencies, and their needless, inconvenient and costly cumbrousness, they are all alike.

We have omitted the ridicule that White heaps upon Webster and others for their practice of giving as definitions of words what are merely metaphorical uses of words. But we cannot refrain from quoting one of his paragraphs on this point:

> And so, at last, we are seriously told that, for instance, "fall," as a verb has 28 meanings, and as a noun 19 (all as well-defined and several of the two-and-seventy stinks that Coleridge found in the city of Cologne), besides 38 which it has in established phrases!

Now if White is even approximately right in his judgment of dictionary definitions of words in common use, it is evident that respecting technical, or even semi-technical, terms, no general dictionary should ever be regarded as the court of final appeal. Yet it is not unusual for one engineer to attempt to refute another engineer's definition of an engineering term by citing a definition in some dictionary. We grant that such citations may serve to call attention to a weakness in a suggested definition, but we insist that they can never be used as if they were authoritative.

Any educated engineer who is well trained in the use of language and logic is far more competent to frame a definition of an engineering term than is the most learned lexicographer. Unfortunately, not every engineer is well trained either in the use of language or of logic. But there is a large number that are thus trained. It is such engineers, and not dictionaries, that are the court of final resort in any dispute over the meaning of an engineering term.

Halls of Fame and Their Futility

One of our contemporaries suggests that engineers should bestir themselves to secure for the profession the honor of having the name of at least one engineer in the Hall of Fame at New York University, New York City. We wonder whether the game is worth the candle. Listen to the definition of "fame" that guides the electors who select the names for this Hall of Fame: "The condition of being much talked about, chiefly in a good sense; or reputation from good achievements."

"Being much talked about" is truly the ordinary criterion of merit, provided the talk be in words of praise. But in order to be one who is "much talked about," it is necessary to be one whose work is readily measurable (or at least seems to be) by the public, which is precisely what an engineer's best work is not. Similarly as to "good achievement," the public (even the educated part of the public) is at best a poor estimator of relative excellence of achievement. So a popular vote on candidates for any "hall of fame" is almost certain to eliminate the most profound brain workers that the world has produced. What, for example, does the public know of the work of Langmuir or of Steinmetz, the two great electrical engineers in the employ of the General Electric Co.? What, indeed, can the public every grasp either as to the striking originality or the profound value of their work? Theirs will never be the sort of fame that leads to "being much talked about," yet theirs is a better fame, and one that no Hall of Fame can enhance in the least.

Gresham's Law and Future Supply of Money

To the Editor: The able article, "Quantitative Analysis of All Factors that Affect Prices and a Formula for Predicting Price Changes" in your April issue, is interesting and valuable.

It is worth pointing out that the future supply of money in the United States may be affected by Gresham's law that "bad money drives out good." Lately Federal reserve bank notes have increased greatly, increasing the ratio of notes to gold, and this ratio may increase more; the same is true of bank deposits.

As you point out, banks lend till the ratio of loans to reserves reaches the "safe" or legal limit (the latter being the opinion of the law-makers as to what is safe). But legislators may make a mistake in establishing the safe limit. Formerly the usual rule was that 25 per cent was considered safe; now that has been changed to 15 per cent, which may be too low (only experience can demonstrate whether it is or not). Gold production in the United States is declining. If we export our gold to other countries the ratio of gold to notes and deposits falls and if it gets near the danger point the tendency under Gresham's law is for notes (bad, unsafe money) to drive out gold (good, safe money) still more rapidly.

If this occurs and note inflation takes place (fiat money is issued by the government) prices will rise. But if, as is more likely, the government does not resort to fiat money (has not a large program of expenditure on hand) banks will call loans which will reduce deposits and prices will drop rapidly due to enforced liquidation.

And so in forecasting the future the gold ratio is important. JOHN WILKES.

Nashville, Tenn.

Gresham's Law, as given in Taussig's Principles of Economics (Vol. I. 269) is:

> The "law" is simply the commonplace fact, long recognized, that where coins of different bullion value circulate, side by side, the poorer, if there be enough of them, will displace the better. The cheaper money metal will be used by preference in presentation at the mint and in making payments; the dearer will be used by preference in the arts or for bullion purposes.

Irredeemable paper currency (fiat money) does not drive out gold, for Gresham's law does not apply to such a case. But gold may leave a country because the balance of trade is against it, or because of differences in premium rates on gold.

Mr. Wilkes suggests that the reduction of bank credits may cause a rapid decrease in deposits, hence in prices. If so, the drop in prices will be attributable to a reduction in the "rate of money turnover," the V in Mr. Gillette's price formula (see our April 7 issue). Mr. Gillette has predicted a reduction of about 20 per cent in V below the 1919 average, during the next year or two, and a consequent reduction in the price level. But he has also pointed out that the highest priced commodities (textiles, foods, etc.), will decrease the most in price and that construction materials will not fall appreciably if at all in price. (See our April 14 issue.)—Editors].

Engineer Graduates in Railway Work

"Why Do Engineer Graduates Shun Railway Jobs?" is the title of a discussion in a recent issue of the Railway Age, in which eight deans of engineering colleges or professors of civil or railway engineering participated. The professors are quite agreed on many points of criticism, and for the most part it appears to be constructive criticism, much of it based on personal experience. A sort of "composite" of these contributed discussions is somewhat as follows:

The railroads generally have failed to keep pace with other corporations in offering even reasonable financial prospects to engineer graduates. Not only have starting salaries been small, but the prospects for advancement have of late years been very small in comparison with outside opportunities. Very little, if any, effort has been made by the railroads to train young men for railroad service. A sad lack of esprit de corps is the case on too many railroads. Capable young engineers have been induced by their engineering instructors to enter railway service but have soon left for lack of proper encouragement. The long working hours, including Sunday and holiday work, for many railway engineers have put a damper on the enthusiasm of many a young engineer. One professor asks the question, "How many railroad engineers are members of country clubs, or of leading clubs in the cities in which they reside, or how many are active in chambers of commerce or in civic affairs?"

Railroad work in itself is believed to be attractive to the average engineering graduate, and many engineers in the service have confessed to a fascination for the transportation business which it is not easy to describe. It is a matter of common knowledge that for a period of several years the railroads have been experiencing "starvation" in a financial way and perhaps in one sense have not been able to compete with outside corporations for the pick of the young engineer graduates. Certain it is that our transportation system is the life of the country and that young engineers are needed now to enter its service and become trained in its organization. As time goes on they will be needed even more than at present to supervise the inevitable expansion of our transportation system.

"You Can't Expect $1,500 Professors to Turn Out $6,000 Engineers."—In an address at the last annual meeting of the Oklahoma Society of Engineers, Dr. Stratton D. Brooks, President of Oklahoma University, said that unless the pay of teachers in universities, colleges and common schools is raised materially at an early date there will be no teachers. "You can't expect $1,500 professors to turn out $6,000 engineers. Our professors are leaving the university for better pay in other lines of duty. The teachers in our schools must make at least a living. Lack of food and clothing makes Bolsheviki and God help America when our school teachers join the Reds, or even have to teach with the pinch of hunger due to scant pay. Professors in the university, like most of you engineers, get less pay than the hod carriers. There's no use of teaching a young man if you must, at the same time, tell him that better pay would await him if he were uneducated."

Some Imaginary Causes of the Present High Price Level

By HALBERT P. GILLETTE, Editor.

When Attorney General Palmer, nearly a year ago, announced that the principal causes of high prices were "profiteering," "extravagance," and "shortage of production," he unintentionally threw dust into the eyes of nearly all newspaper editors, and they in turn have been unintentionally blinding the public ever since. Every one of these three "principal causes of high prices in America is an imaginary cause.

In the April 7 issue of Engineering and Contracting I showed that our per capita productivity never was greater than it was in 1918, and that the data for 1919 that are available prove 1919 to have been as big a year as 1918 in per capita productivity.

Frank A. Vanderlip, Otto H. Kahn and other well-known bankers have been delivering speeches and issuing pamphlets to the effect that "shortage of production" is one of the main causes of high prices. Their names have seemed to most editors as being a sufficient guarantee that they were stating facts. But those of us that belong to the engineering profession have learned that it is risky to accept statements based merely upon "authority." We demand the data upon which the statements are founded. When we look to Messrs. Vanderlip, Kahn and Palmer for the data that have convinced them that there is shortage of production in America, what do we find? We find quotations of statements by a few managers who have told them that their workers are less efficient than they used to be. From such data they leap the chasm between the output of a few thousand workers and that of the forty million workers in America. In short they generalize from insufficient data. And the pity of it is that they generalize where no such process of inference is necessary, for the government itself has printed all the data needed to show what our national productivity has been, every year prior to 1919. Moreover, sufficient data as to 1919 are available to indicate that the per capita output in 1919 was fully equal to that in 1913.

In my article entitled "A Quantitative Analysis of All Factors That Affect Average Prices" (Engineering and Contracting, April 7), will be found all the data needed to convince anyone that American per capita productivity did not decrease during the war, and that it was as great in 1919 as it was in the year before the war. I insist, therefore, that the alleged authorities on finance and economics who are attributing high prices to shortage of production in America answer data with data, and not with inferences.

As to profiteering and extravagance, there is less need of statistical evidence, for it can be readily deduced from premises that are incontrovertible that neither of these "causes" of high price level is a cause at all.

Extravagance is a term used to designate the expenditure of income for commodities or services that are regarded as being either "unnecessary" or in excess of "reasonable" requirement. Thrift is the opposite of extravagance. But income "saved" through thriftiness is "saved" only to be expended. The thrifty man curtails his expenditures in "extravagant" directions, but only to increase them in "thrifty" directions. For example, he may buy cheaper clothing and live in cheaper quarters, in order that he may build a home or lend money to some one else who is building a home. His "savings" are not hoardings. He saves that he may spend, or that someone else may spend his money, in the latter case receiving interest for the use of his money.

Statistics verify the statement that the entire income of a people is spent every year, the larger part going for things that are consumed at once, while the smaller part (about 10 per cent of the total) goes for the things that are called "permanent investments"—houses, machinery, plant, etc. But shallow and hasty reasoners think that "saving" somehow does not involve spending; hence their sophistical inference that if every one would become thrifty the general level of prices would fall. What would happen were every one to become thrifty would be merely a diversion of money from certain expenditures regarded as extravagant to certain other expenditures not regarded as extravagant. The effect of this diversion of expenditures from one channel to another would be to cause the prices of certain commodities to fall, whereas the prices of certain other commodities would rise. Silks, furs, diamonds, etc., would decrease in price, but lumber, brick, cement, machinery, etc., would rise in price.

The following generalization is incontrovertible: The level of average prices of all commodities is not changed by any diversion of expenditures from one class of commodities to another class.

For precisely the same reason that extravagance does not affect the general price level, profiteering does not affect it. All that profiteering does is to divert income from certain classes of expenditures to other classes. The profiteer takes more than a "fair profit" for his services. By as much as his profit is excessive by that much does he reduce the buying power of the customer whom he "robs." But, on the other hand, by exactly the same amount does the profiteer increase his own buying power. The customer who has been thus "robbed" might have used the "stolen" money to buy shoes, whereas the profiteer may use it to buy a hat. But the total buying power remains unaltered because of the "profiteering"; hence the total demand for commodities is not changed because of profiteering; hence the average price of commodities is not affected by profiteering. Profiteering, therefore, is a "straw man" in so far as the high-price level is concerned.

In this connection it may be well to remind the reader that all income is in the final analysis, spent for commodities. Those that earn their income by professional or personal service spend most of it for commodities; and what they do not thus spend is either paid to or loaned to those that do spend it for commodities.

High taxes are not a cause of high average prices of commodities, except in so far as they cause a decrease in the per capita productive output of commodities. High taxes divert income, but they do not affect the price level unless they are used to take workers from productive enterprises and employ them in unproductive government work. To a relatively slight extent only are taxes now being used to maintain government employes who should be engaged in productive work. Hence several of the arguments in Otto H. Kahn's recent pamphlet, "Two Years of Faulty Taxation" are as faulty as the tax system itself. He says:

> We have had a two years' test now of a scheme of taxation which is unscientific, inconsistent and ill designed. The result is writ large in the high cost of living, industrial and economic disturbance, and social discontent.

With his first sentence we may concur, but we can not agree with his second sentence.

Let us direct our attention to the four factors that do affect price levels and avoid "fighting windmills," such as profiteering, extravagance, shortage of production, and high taxes. The four factors are: (1) Currency, (2) Rate of money turnover, (3) Population and (4) Per capita productivity.

8x8-Ft. Rock Tunnel Driven at Rate of 9 Ft. Every 8 Hours.—An 8x8-ft. tunnel at the Holmes Mine at Ishpeming, Mich., was advanced 484 ft. in 432 hours' working time, according to the Engineering and Mining Journal. This work not only involved the drilling, blasting, breaking and tramming of 30,976 cu. ft. of rock, but the hoisting thereof to a height of 1,300 ft. and its disposal from that point. The record was made in October, 1919. The rock is diorite, dense and hard, a phase of massive greenstone. Some idea of its hardness is shown by the fact that 80 per cent gelatine was used for blasting. The daily working time was 16 hours, being divided into two 8-hour shifts. Each shift crew totaled 10 men, consisting of four miners and six muckers and trammers. No. 248 Leyner-Ingersoll drills, equipped with anvil block chucks, were used exclusively for the drilling. These machine were supplied with 1¼-in. hollow hexagon steel having 4-point crossbits, all of which were machine sharpened. Starters were 24-in. long with 2¼-in. gage, and this was reduced 3/32 in. with each 18-in. change in length of steels. The standard "V" cut was used in drilling, requiring from 17 to 19 holes, or more than 100 ft. of drilling per round. Two machines were mounted on a shaft bar, three set-ups being necessary for one full cut of 9 ft. Two top cuts were drilled and blasted before shooting the bottom holes.

Use of Heavy Tractors for Hauling Elevating Graders and Wagon Trains from Steam Shovel

Three artillery type tractors designed by the War Department for military use were employed last year by the U. S. Reclamation Service in the construction of the Salmon Lake Dam and Conconully dam enlargement of the Okanogan Project, Washington. The following description of the work of these tractors has been prepared from an article by L. V. Branch, Engineer, U. S. R. S., in the March Reclamation Record, and from additional information furnished us by Mr. Branch.

Description of Tractors.—The tractors are "Caterpillar" tractors, designed by the War Department as "10-Ton Artillery Tractor, Model 1917." The weight of the machine, with full equipment, is 21,500 lb. The tracks are 15 in. wide and have 96 in. of ground contact, giving a ground pressure of only 7½ lb. per square inch. The machine has three speeds forward and one reverse; at 600 r.p.m. engine speed the road speeds are 1.47, 2.71, and 4.19 miles per hour forward and 1.09 miles per hour reverse. The drawbar pull on direct (second speed) is 5,200 lb. and on low (first speed) 8,000 lb.

The general design and construction of the engine and transmission machinery of the tractor is similar to that of a high-class motor truck, except that two extra dry-plate multiple-disk clutches are necessary in order to furnish independent drive for the two tracks. The engine is the 4-cylinder, 4-stroke cycle, valve-in-head type, with bore of 6.5 in. and stroke of 7 in., which at 600 r.p.m. develops 55 HP. The tractor is equipped with K. W. Model H. K. high-tension magneto with impulse starter, 2-in. Kingston carburetor with Stewart vacuum feed system, dry-plate multiple-disk master clutch, and selective sliding-gear type transmission.

Operating Conditions of Tractors.—One tractor was used for 3 months (August, September and October, 1919) for pulling a standard Western elevating grader operating in a borrow pit of fine sand and silt. This elevating grader was loading 1½ cu. yd. dump wagons hauled by 3-up teams to embankment. The other tractors were used for four months hauling wagon trains from the steam shovel borrow pit to the embankment. As the length of haul was short (1,000 ft.) and turning space limited it was considered essential to have tractor train equipment that could turn in narrow spaces. The tractors can turn completely around within their own length; the wagons used as trailers were of the common cut-under dump-wagon type having a capacity, level full, of 3 cu. yd. These wagons, although of heavy substantial construction, were not designed for the heavy use to which they were subjected on this job. The bill for repairs on the wagons was accordingly heavy; about double the repair bill for the team-drawn wagons.

The reversible type of trailer, where the tractor may change to the opposite end of a tractor train at the end of a trip, was not used on this job on account of the short haul and because the above type of trailer can not be turned within as narrow limits as the cut-under type of wagon.

Under usual conditions the tractors easily handled three of these 3-yd. wagons, but under adverse conditions of wet ground and on grades for short periods they could handle only two trailers. On any rough, soft ground or on upgrades with loads the tractors were operated in low gear; on level, hard ground or down grades with load, pulling elevating grader, or when running light, the engines were operated on intermediate direct-drive gear. High gear was not used at any time. The tractors had to be brought to a stop to change gears as they have little coasting power.

Steam Shovel Loading Tractor Trains with Gravelly Material for Embankment.

Tractor Operating Costs.—Due to the repeated stopping and starting of the tractor pulling the elevating grader and the time required for dumping and loading the tractor trains, the mileage per day for the machines was low. The following tabulation gives average mileage per day, also gasoline and lubricating oil consumption by months.

TRACTOR OPERATION: GAS AND OIL CONSUMPTION.

1919.	Tractor days worked.	Miles traveled.	Average miles per day.	Gallons of gasoline used.	Miles per gallon of gasoline.	Gallons of lubricating oil used.[1]	Miles per gallon of lubricating oil.
August	62	659	10.6	1,988	0.33	117	5.6
September	63¼	695	11.0	1,955	.36	116	6.0
October	61	650	10.7	2,023	.32	113	5.8
November	37½	417	11.1	1,136	.29	69	6.0
Total	223¾	2,421	10.8	7,402	0.33	415	5.8

[1] Engine and transmission oils; hard oil and track oil not included. Lubricating oils removed from engine were used on tracks; at other times black oil was used for track oil.

Tractor No. 3 did over 90 per cent of the elevating grader work. The miles traveled per day were lower on this class of work; hence this machine shows the highest cost per mile traveled but not the highest daily cost.

The depreciation charged per tractor was $200 per month; this resulted in excessive unit costs where a tractor was laid up some time for repairs. More uniform costs would result if the depreciation was figured on a mileage or day worked unit. For future work this depreciation charge, states Mr. Branch, can safely be somewhat lower than shown in the following table:

THREE ARTILLERY TRACTORS. OPERATING COSTS, FOUR MONTHS, AUGUST TO OCTOBER, 1919.

	Total costs.	Unit cost per mile operated.	Unit cost per operating day.
Gasoline	$2,111.80	$0.87	$ 9.12
Lubricants	629.60	.26	2.81
Operator	1,391.34	.58	6.21
Repairs	697.22	.29	3.11
Miscellaneous supplies and expense	563.21	.23	2.52
Equipment depreciation	2,400.00	.99	10.72
Total and mean	$7,793.17	$3.22	$34.79

Note.—Gasoline $28\frac{1}{2}$ ct. per gallon. Operator $5.50 per day. Miscellaneous expense covers, among other things, the cleaning, oiling and greasing of tractors between shifts.

Starting Embankment Construction for Salmon Lake Dam. View Taken from Site of Outlet Structure. Puddling Back Fill of Cut-off Trench Along Line of Wakefield Sheet Piling 6 in. Thick by 38 ft. Deep. Steam Shovel and Elevating Grader Working in Borrow Pits on Right of View.

Operating Difficulties.—Throughout August very dry weather prevailed and during this month the tractors, when off the dam, worked in a cloud of dust that rendered them almost invisible at a distance. At this time much difficulty was experienced with carbon in the cylinders of all the tractors. This carbon was in the form of dry flakes or balls that repeatedly short circuited the spark plugs and caused several delays each day.

Analyses of the deposits taken from the engine cylinders during this period showed the following results:

TESTED BY BUREAU OF STANDARDS, SAN FRANCISCO.

	Per cent.
Sample 1—	
Carbonaceous matter	60
Mineral matter or dust	40
Sample 2—	
Carbonaceous matter	40
Mineral matter or dust	60

TESTED BY DEPARTMENT OF CHEMISTRY, STATE COLLEGE OF WASHINGTON.

	Per cent.
Sample 1—	
Carbon	11.11
Dust or fine sand	58.86
Iron—Considerable.	

A change of lubricating oil for the engine was made from an oil manufactured from an asphaltic base crude to one made from a paraffine base crude oil. Thereafter almost no difficulty was experienced with carbon deposits. It happened, however, that welcome rains greatly reduced the amount of dust in the borrow pits at the time the change in oil was made, so it is difficult to state how much of the improvement was due to the new oil and how much to the reduced amount of dust.

When clearing the dam site the tractors were found to be excellent stump and brush pullers. A ¾-in. steel cable was used for this work, experience showing that a ⅝-in. steel cable would not hold the machines. In this class of work, the repeated pulling, backing, and turning in small areas causes the tracks to pick up considerable gravel and several track-supporting roller brackets were broken in this way. The difficulty can be obviated by allowing the machine to move either forward or backward far enough to clear the tracks of gravel.

The most serious delays for repairs to tractors during the season were due to grousers (cleats on tracks to increase traction) becoming loose and either catching between the track and frame so as to break the track supporting roller brackets or flying free at one end and, in going around with the track, stripping the overhanging gasoline tank from the frame. The loosening of grousers was not always due to failure to keep grouser bolts tight, but was usually caused when the tractor passed over rocks projecting from frozen ground in such a manner that a considerable portion of the weight of the machine came on a deep point of a single grouser. This caused spreading of V-shaped grouser and release of the tightening bolt.

An attempt was made to operate the machines without the grousers, for the tractors are much easier to operate when running on the flat plate tracks; but for this work they did not have sufficient tractive power unless the grousers were on the tracks. Even with the grousers on the power of the engine is sufficient, in medium or soft soil, to rotate the tracks under the machine when the tractor is stalled.

The wear of the tracks caused no trouble during the past season. A few new track links and track pins will be inserted when overhauling the machines, but in general there is much more service in all the tracks.

Economy in Use of Artillery Tractors.—On account of the lack of traction in the loose dry silt and fine sand in the elevating grader pit the use of a wheel-type tractor for pulling that machine would have been impossible, while the artillery tractor did excellent service.

In hauling earth on the dam the tractors always hauled from the steam shovel pit and the teams from the elevating grader pit, except for short, irregular periods when the teams also hauled from the steam shovel. During these short periods, when the teams hauled from the shovel in competition with the tractor trains, the conditions were abnormal; so it is impossible to give hauling costs where teams and tractor trains did identical work. The hauling to the dam was done, however, under the same supervision and the same labor conditions. Costs of hauling are given as an item in the following tabulations of costs of material placed in the Salmon Lake Dam embankment.

Of the above, 19,169 cu. yd. were fine sand and silt, average haul 600 ft., vertical lift 7 ft. to 18 ft.; and 21,827 cu. yd. were sand, gravel, and boulders, average haul 1,000 ft. down grade. Worked 90½ shifts; average per shift, 453 cu. yds. Average size of loads per wagon, 3.39 cu. yd.

The shovel, a 35-ton revolving, 1¼ cu. yd. dipper, was not worked to capacity by the two tractor trains; considerably better results would have been shown if three tractor trains had been worked.

Pitman and common labor, $4.36-4.20 per day.
Labor costs do not include superintendence.

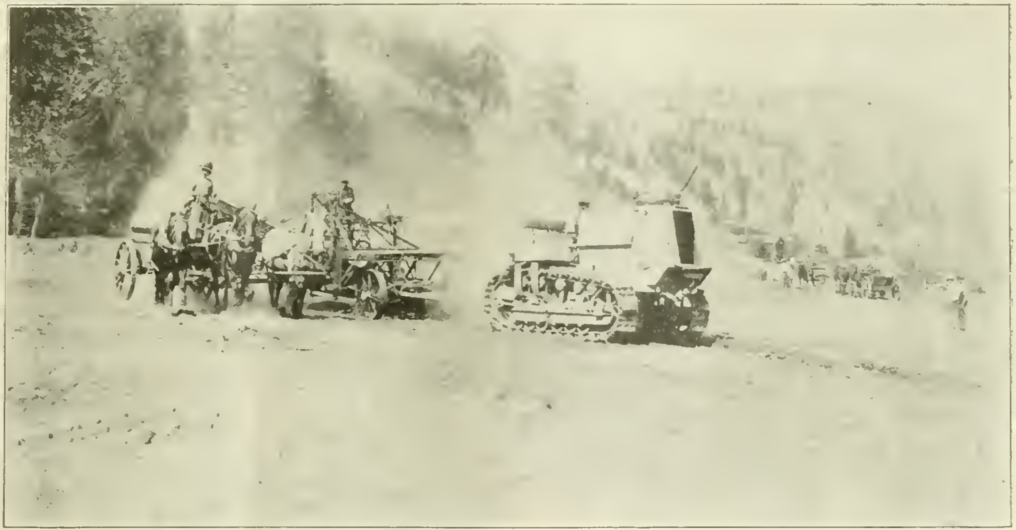
The following table shows the cost of excavation and hauling:

EXCAVATION AND HAULING FROM STEAM SHOVEL PIT TO SALMON LAKE DAM.

	Cubic yards, borrow pit measurement.	Total cost.	Cost per cubic yard.	
Shovel operations, labor, supplies, plant and depreciation charges	40,996	$ 6,241.80	$0.152	
Hauling by tractor trains	39,595	6,391.60	.161	$0.195
Repairs to wagons and minor expense chargeable to hauling	39,595	1,363.69	.034	
Hauling by teams	1,101	306.19	.219	
Total	40,996	$14,303.28	$0.349	

EXCAVATION AND HAULING FROM ELEVATING GRADER TO SALMON LAKE DAM

	Total cost.	Cost per cubic yard	
Operation of elevating grader, including all plant and depreciation	$ 724.29	$0.029	
Operation of tractor, including depreciation charges	1,956.23	.055	
Hauling by teams	6,580.29	.185	$0.201
Repairs to wagons and minor expense chargeable to hauling	571.36	.016	
	$9,832.17	$0.276	



Elevating Grader Drawn by 55 H.P. Artillery Tractor Loading Dump Wagons with Core Material.

The cost of the steam shovel operation is shown in the following table:

August to Nov. 1, 1919.	Per cent.	
Digging, including waiting for wagons	76.2	
Moving up	2.7	
Moving to new work	2.2	
Total operating time		81.1
Repairs to motive power	3.3	
Repairs to traction machinery	1.5	
Repairs to other machinery	3.8	
Total repair time, not including Sundays		8.6
Time washing boiler, maintenance and other Sunday or holiday work		10.3
Total		100.0

COST OF SHOVEL OPERATIONS.

	Total.	Per cu. yd.
Labor, machine crew	$1,414.60	$0.035
Labor, ground crew and pitmen	1,143.55	.028
Labor, miscellaneous, men and teams	42.17	.001
Fuel, 114.5 cords of wood, delivered to shovel	1,094.35	.027
Cost of water	145.12	.004
Cost of lubricants	41.61	.001
Moving to new work	261.80	.006
Equipment repairs and supplies	580.59	.013
Minor miscellaneous expense	149.51	.004
Plant charges, proportion of hauling and erection of shovel	406.50	.010
Equipment charge, transfer cost $5,893.35, depreciation 4 months at 4% per month	962.00	.023
40,996 cu. yd. loaded into dump wagons	$6,241.80	$0.152

Shovel crew paid union scale as follows:
Engineer, $175 per month and board.
Fireman, $90 per month and board.

Of the above 35,600 cu. yd. borrow pit measurement, were fine sand and silt, average haul 600 ft., vertical lift gradually increasing from 7 ft. to 19 ft. Worked 69 shifts; average per shift 537 cu. yd. Average size of loads 1.37 cu. yd., borrow pit measurement.

The material as placed in the dam shows a shrinkage of 11½ per cent as compared to borrow pit measurement. The labor and supply cost for spreading, sprinkling, and compacting the material placed in the embankment was just under 6 ct. per cubic yard. The total cost of placing 73,558 cu. yd. of embankment was $32,478, which gives a unit field cost of $0.441.

As noted in the above tabulations, the hauling by teams cost 20.1 ct. per cubic yard while the hauling by the tractors cost 19.5 ct. per cubic yard. The conditions of the two hauls did not vary greatly; considering the entire period, the teams had the poorer roads and slightly more of adverse grades but the advantage of 200 ft. shorter haul.

Based on the experience of the past season under the conditions existing on this work, it is Mr. Branch's opinion that these tractors, when used for transporting earth, will show greater economy, as compared to hauling with teams, when the length of haul is greater than the average haul of 700 ft. and on poor roads and steep grades where teams must be given frequent rest periods. As the length of haul gets shorter and the roads and grades improve the teams will prove cheaper because they can be kept moving more steadily than the larger tractor units and they can make quicker turns at the end of the trip.

The above has taken no account of the question of maintaining an organization. The operation of the tractor requires the service of an operator and about half time of a repair man, both men of considerable reliability. The tractor, when working, replaced six 3-horse teams requiring the services of six teamsters who were hard to secure and much harder to keep on the job.

Methods, Costs and Results of Survey for Logging Railroad

In the western part of the state of Washington, where the survey to be described was made, it is a very common practice among logging operators to have their roads located by foremen or superintendents. These men's knowledge of engineering is comparatively small and their other duties tend to make them slight the location problems. An increasing number of logging firms, however, are appreciating the falseness of economy of this sort, and are employing competent engineers to make their locations.

Some readers unfamiliar with logging operations will find it difficult to understand their apparently careless attitude on the part of the operators. For their benefit it may be mentioned that logging has usually been conducted in a very loose manner with an eye chiefly to the large features, and without much attempt at minor economies. The handling of logs on the ground by its very nature invites and even requires rough and ready methods. There can be little doubt that the psychological effect of this is to incite similar methods throughout the entire business.

A few engineers have devoted their attention almost exclusively to this work, and are appropriately classified as "logging engineers." Of these, the writer is not one. When asked if he could make a logging road survey and location, his reply was that he believed he could do it satisfactorily if he were furnished certain information which could be combined with the principles of highway and main line railroad location.

The work was undertaken on this basis, and its success may be judged by the facts that the line was subsequently inspected and approved by an expert of recognized standing, with the comment that he had never seen a line so closely fitted to the ground. Although the cost of the survey was more than twice what was originally expected, the manager, on paying his bill, volunteered the information that he considered it money well spent.

Data and requirements of the line are as follows:

Air line distance between termini	1.25 miles
Total length of located line	2.55 miles
Net rise in elevation	585 ft.
Locomotive to be used	65-ton Shay
Limiting grade	8 per cent
Limiting degree of curvature	22°

The country was quite rough, consisting in the main of side hills broken by numerous deep gulches, but unlike most Western Washington country, with very little underbrush.

The survey was practically a miniature of a main line job. As elevations were unknown, the first step was a barometer reconnaissance. Section corners and lines were marked, so that locations were accurately known. The barometer (one only was used) indicated a difference of elevation of 855 ft.—an amount subsequently found to be 270 ft. or nearly 50 per cent too high. Fortunately this led to no serious inconvenience, but it served as another warning that where matters of importance are to be decided barometric work should be treated with great care.

The grade of an old logging road, abandoned a number of years previously, extended from the mill for more than a mile in the general direction to be followed, and it was evident that the greater part of this could be used to advantage.

The preliminary survey was made by stadia by a transitman and two rodmen. Azimuths were read to the nearest 15 minutes only, and were frequently checked by compass. No plumbbob was used, the transit being set by eye over the stakes. The survey began at the upper end of the line and ran down as nearly as was possible on a 6 per cent grade, the angle for this being set off on the vertical circle and the head rodman moved up or down the side hill until he reached grade.

The first line was designated "A Line," and transit points were numbered consecutively beginning with one. No intermediate stakes were set. The head rodman's chief responsibility was to pick approximately suitable transit points, after which he was moved to grade by the transitman. The rear rodman, in addition to giving back-sights (rod and vertical angle were always read both forward and back) measured side slopes by clinometer and recorded them, and blazed enough trees to make the transit point easily found later. The longest sight was 524 ft.

The "A" Line crossed 5 gulches, thus tending to make construction expensive, and was located rather too far down the hill for convenient logging, modern methods of logging by cable and donkey engine making it desirable that the logs be hauled up hill rather than down. A new preliminary was therefore run on a bench which brought it above the heads of all the gulches but one. It involved, however, considerably more 8 per cent grade than did the "A" Line, and also had about ¼ mile along a hillside of slope varying from 30° to 40°. Two other short preliminaries were run, and several hours were spent in inspecting other ground for possibilities. The clinometer was depended upon as much as possible for topography, but in the gulches and at some other points, stadia side shots were taken. Weather was very bad much of the time—rain, snow and fog making work difficult.

The data of these surveys are as follows:

Hours going to and from work	10
Hours actually worked	29
Number of points occupied by transit	102
Miles of line run	3.02
Number of side shots	109
Cost of preliminary survey	$206

For the most difficult section, involving a little more than a mile of length, four lines were projected on the map and comparative estimates made. Fortunately, the cheapest line was also the one best adapted to the needs of logging operations, although it involved more 8 per cent grade than did any of the others.

Of the total located line, slightly more than half was on curve, and the total number of curves was 46. The first 4000 ft. lay almost entirely on the old grade previously mentioned, and much difficulty was at first experienced in fitting the line to it satisfactorily. The advantages of a little careful engineering showed plainly here—first, in a river crossing which had originally involved a bridge 144 ft. long. The bridge was now gone and without materially lengthening the line of introducing any objectionable features, this length was reduced to 104 ft. Secondly, there was a 50° curve leading directly to a gulch crossing where there had been a bridge (since burned) about 90 ft. long and 20 ft. high. A half day's careful work replaced the 50° curve with a 22°, shortened the necessary bridge to 70 ft., lowered its height to 16 ft., and left the length of line unchanged.

The new line required about 140 yd. of earth excavation, but this was little, if any more than that in the abandoned portion of the old line. At other points on the grade were extensive cuts—two of them partly in rock—which were very largely unnecessary. The location of 4,000 ft. along the old grade, including the already mentioned relocation of curves and bridges and the running of final levels consumed 23 hours' actual working time of the party of 3 men. Its cost was $155.

The new location amounting to 9,450 ft. of finished line, and involving 4,800 ft. of trial lines afterward abandoned, occupied 85 hours' working time for the same party, and cost $545.

Stakes were set at 50 ft. intervals on the flatter curves and at 25 ft. on the sharper. No hubs were set, but the transit plumbob was used on the stakes. Distances were chained to the nearest 10th ft. Preliminary surveys and topography had been platted at a scale of 200 ft. to the inch with 10-ft. contour intervals, and projections made upon this map. Platting, projection and estimates cost $82.

Location followed the general course of the best of these projections, but in view of the close fitting of the line to the ground, it was necessary to work out details as the location proceeded.

The roughness of the ground, the very frequent interference of trees, and the small size of the party led to the use of a variety of methods. On steep portions of the line, the preferred procedure was to set the vertical circle of the transit at a grade of 8 per cent, and then send a rodman ahead to find the grade location. This having been done, if he was on a tangent he proceeded to choose a P. I. From this P. I. the position of the tangent ahead was generally determined in the same manner, but in a few instances there was sufficient change of slope near the P. I. to interfere with the method, and in these cases the engineer determined the position of the line by hand level or clinometer. The longest tangent so established was 340 ft. In a good many instances the P. I.'s were not easily accessible, and in such cases trial curves were run from a selected P. C., the hand clinometer being used freely in finding the desired grade. Sometimes the first trial gave a satisfactory location, but in other cases it did not, and in some instances the third trial was necessary. Short curves, established from a P. I. and deflection angle, were mostly located by tangent offsets. A small offset table prepared by the writer when engaged on highway location a number of years ago made this a very speedy and convenient method.

The thick growth of trees continually presented problems in the passing of obstacles. In one instance an entire curve (fortunately a rather short one) was located by ordinates from the long chord. Where curves were run by deflections, it was frequently necessary to locate a point by middle ordinate from a 100-ft. or a 50-ft. chord.

The line was not cross-sectioned, but center cuts and fills were marked on all stakes. Miscellaneous engineering expenses amounted to $42, and the total cost to $1,030, which it will be noted is $400 per mile, or slightly less than 30 per cent of the total estimated cost as given below:

ESTIMATED COST (FEBRUARY, 1920) OF LOGGING ROAD.

Note.—Costs are intended to show costs to this company, and are not necessarily of general applicability.

Station 0/00 to 130/00	2.46 miles
Tail of switch-back, 450 ft.	.09 miles
Total	2.55 miles
Clearing and grubbing, 103 stations at $10	$ 1,030
Grading—	
Repairing old grade, 31 stations at $25	775
Excavation, new line, 5,500 cu. yd. at 60 ct	3,300
Borrowed fill, 1,100 cu. yd. at 60 ct.	660
Crib logs, 1,000 lin. ft. at 30 ct.	300
Bridges, 330 lin. ft. at $12.50	4,125
Ties (3,000 per mile), 7,650 at 60 ct.	4,590
Rails, second-hand 60-lb., 240.5 tons at $54	12,987
Rail fastenings and joints, 2.55 miles at $800	2,040
Switch sets, 2 at $75	150
Ballast, 2.5 miles at $400	1,000
Track laying and surfacing, 2.55 miles at $800	2,040
Engineering	1,000
Supervision	500
Total	$34,497
Contingencies, 10 per cent	3,450
Grand total	$37,947
Total cost per mile	14,900

"Beating the Bounds"

Dr. E. Deville, Surveyor General, Department of the Interior, Ottawa, Canada, in a paper read at the annual meeting of the Association of Ontario Land Surveyors, has the following to say concerning landmarks:

At the time of the Roman Empire, a festival called Terminalia was celebrated on Feb. 22 in honor of Terminus, the god of landmarks; it took place at the boundaries where sports and dancing were indulged in.

The ancient custom of "Beating the Bounds," still observed in many English parishes, probably originated from the Roman Terminalia; it is as old as Anglo-Saxon days, as it is mentioned in laws of Alfred and Athelstan. The priest of the parish, with the churchwardens and parochial officials, headed a crowd of boys who, armed with green boughs, beat with them the boundary stones. Sometimes the boys were themselves whipped or even violently bumped on the stones to make them remember. Obviously, boys were selected to ensure that the witnesses to the boundaries should survive as long as possible.

Street Car Fares Increased in Over 200 Cities.—Of the 273 cities in the United States having a population of 25,000 or more, increased street car fares in some form or another are now in effect in all but 56 cities. In 196 of these cities the cash fare is more than 6 ct.; in 64 it is more than 7 ct. and in 34 it is more than 8 ct. In all but 15 of the 68 cities, having more than 100,000 population, the cash rate is more than 5 ct.; in 40 of the 62 cities between 50,000 and 100,000, it is more than 5 ct., and in 103 of the 142 cities having less than 50,000 it is more than 5 ct.

The Cause of Brittleness in Steel Rails

An interesting and concise statement of the above subject is given as Appendix H of the report of the Committee on Rail, of the American Railway Engineering Association, presented at the March convention in Chicago. This appendix is written by Mr. M. H. Wickhorst, the committee's Engineer of Tests, and we quote from it as follows:

When a rail breaks in track or in test with little or no noticeable bending or display of ductility, it is usually called brittle, or the cause of the breaking is said to be brittleness. In this discussion it is proposed to consider the nature of brittleness and the underlying causes of it.

When a rail is bent in the drop test or other bending test, it may display brittleness with either the head or the base in tension. When a rail shows brittleness when tested with the head in tension, an examination of the fracture shows that the first point of the break was in the interior of the head and that the fracture radiated toward the surface from the interior point. In other words, in the case of head tension breaks, brittleness is a condition of the interior mteal of the head, although the metal at the top of the head may be subjected to greater strain.

When brittleness is shown when tested with the base in tension, the initial point of the break may be in the interior of the base, particularly with thick base rails, or it may be a surface seam in the bottom of the base.

Head Brittleness.—Brittleness with the head in tension may be divided into two types: one, in which the break starts in an area of fine crystalline structure of segregated carbon and phosphorus; the other, in which the break starts from a small area of slightly different appearance, called a "gray spot," which has been found to be a small interior crack, in otherwise normal appearing structure.

Although with our present information, there is a possibility that the gray spot is not strictly a crack, it is at least a "near crack," and it will be called a crack for simplicity of discusssion. When such a rail is put into service, some of the cracks, especially those not so deeply imbedded in the rail head, grow under the continued action of moving wheels and develop into "transverse fissures" surrounding the original crack, which acted as a "nucleus." The fissure continually grows in service, becoming larger and larger, until finally it comes to the surface at the side of the head and at this stage may cause sudden fracture through the whole section of the rail.

Illustrations of transverse fissures in various stages of development are given herewith. The last one in the series shows the fissure as a dark area, as it had grown until it reached the surface at side of the head, and thus had become discolored by the action of the weather.

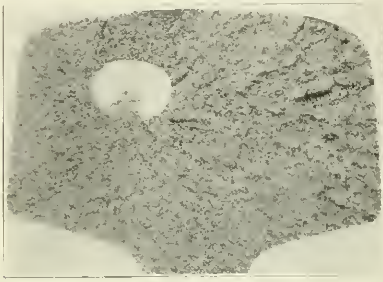
Base Brittleness.—Brittleness with the base of tension results from a condition of segregation of carbon and phosphorus in the interior of the section extending down into the base or from a longitudinal surface seam in the bottom of the base. In the former case the break starts in the interior due to the brittleness or lack of ductility of the interior metal This kind of brittleness is of the same nature as head brittleness due to interior segregation, but because segregation generally extends farther into the head than into the base, it can be more readily detected by bending the rail with the head in tension than with the base in tension. Therefore in the inspection of rails, they should be tested with the head down.

Most rail failures of the type known as "broken" rail, showing either a "square" or "angular" break without visible defect in the metal, start from a seam in the base. In the drop test, too, of new rails, a seam in the base may be the origin of a break with but little display of ductility, particularly when tested with the base in tension. If a seam occurs in the base where it rests on a support, the local compression of the metal caused by the blow opens it up, starting a split in the base and resulting in fracture through the whole section about 6 in. from the support.

When tested with the head in tension, if a seam occurs in the base where struck by the tup, the flange is apt to break off before the tensile ductility of the head is exhausted.

The primary purpose of the drop test is to determine the tensile ductility of the rail, but as just discussed, a seam in the base may cause a break before the full ductility of the part in tension is obtained. This may be true with either the head or base in tension. When, however, the rail is bent by a hydraulic bender or a screw operated test machine, a normal break due to the exhaustion of the tensile ductility is obtained, uninfluenced by the presence of seams. And comparisons have shown that the ductility is the same whether the rail is bent quickly as in the drop test or more slowly as in the hydraulic test. (The latter method is usually spoken of as the "quick bend" method, as the whole operation of testing the rail is more quickly performed by this method.) As seen from this discussion, the hydraulic bend method is preferable to the drop test in that it always gives normal tension breaks of the part in tension.

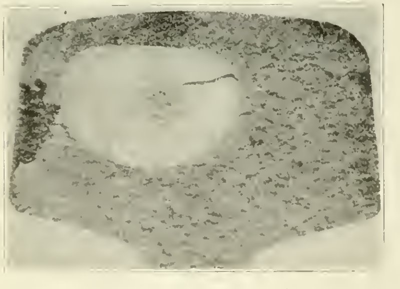
Segregation, Slag and Sulphur.—The segregation of carbon and phosphorus that occurs toward the interior and upper part of the ingot while the metal is setting is a cause of longitudinal brittleness when the rail is bent in testing. In service also, segregated metal frequently causes the type of rail failure known as "split head" by causing transverse brittleness of the interior metal of the head.



Transverse Fissure Partly Surrounding the Nucleus.

The rolling of the wheels over the rail causes a side spread of the top part of the head, although the exterior metal has sufficient ductility to flow without breaking the interior metal may not have sufficient ductility to stretch sideways, due to locally excessive carbon and phosphorus, to non-metallic inclusions or to discontinuities, and a break results which finally develops into a split head.

It sometimes happens in the process of manufacture that small particles of slag remain entrapped or emulsified in the steel, which become elongated into thread-like inclusions in the rail. Unless very numerous or large, these inclusions do not much affect the tensile properties of the rail steel longitudinally, but they lower the ductility in a transverse direction, producing a "woody" structure in the fracture.



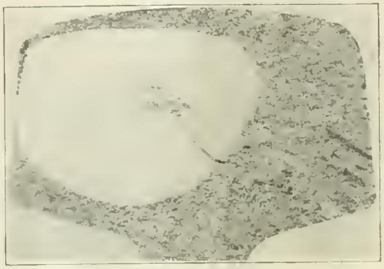
Well Developed Transverse Fissure.

Sulphur occurs in steel mostly in the form of the non-metallic compound, manganese, sulphide, distributed as a finely divided inclusion, and ordinarily has little influence on the physical properties of the steel when the sulphur is low. Sometimes, however, especially when the sulphur is high, the manganese sulphide collects into larger masses, forming elongated threads in the finished rail similar to slag inclusions, with the same effect on the physical properties. These non-metallic inclusions constitute in effect discontinuities in the metal and form starting points for rail failures such as split head (vertical longitudinal crack in the interior of the head) and horizontal fissure (horizontal longitudinal crack, generally with a transverse fissure branching off from it).

Remedies for Brittleness.—It is intended at this time to indicate only the general nature of the means necessary to remedy brittleness of steel rails.

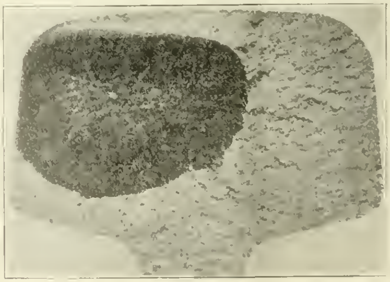
Two entirely independent conditions may be causes of brittleness in steel rails; one, the interior segregation of carbon and phosphorus and the other, longitudinal surface seams in the bottom of the base. To a lesser extent slag and manganese sulphide inclusions may also be causes of brittleness. Then, too, there are interior cracks, our knowledge of which is just in process of development.

Segregation is a condition that originates in the making of the ingot and to keep it at a minimum, the steel should be well deoxidized with silicon, titanium or other means. A liberal discard should also be made from the top of the ingot, unless some form of "hot-top" process of casting the ingot is used whereby all the segregate is collected at the top instead of the interior of the ingot. As a matter of steel economies, probably the simplest and most economical method would be to roll the top part of the ordinary rail ingots into other products, and for this reason it seems desirable to find as many uses as possible for this material and thus expand its market.



Transverse Fissure Almost Developed to Surface at Side of Head.

Surface seams originate in the rolling, and result especially from the tearing of the sides in the early stages of rolling the ingot into a bloom. The surfaee of the ingot is very tender and the two open sides as the ingot first enters the blooming rools are apt to be ruptured. Such tears are not afterwards eliminated and rolled out but are rather "rolled in," forming seams in the finished product. The seams are not usually visible in the rails, due to the varnishing over of the surface by the surface slag in rolling. Pickling in strong acid, however, brings them to view.



Transverse Fissure Developed to Surface and Darkened by Weathering.

The avoidance of seams depends on the skill and care used in heating the ingots in the soaking pits, and the method and care used in the making of the bloom. When the ingot is rolled in the usual box rolls, the draft should be small in the first few passes and the ingot should be turned after each pass for the best results as regards the surface of the bloom formed. When the ingot is rolled in diamond or V-shaped rolls, the four sides are supported, leaving only two of the corners open, where the tearing then occurs. These corners finally form the edge of one flange, and an upper corner of the head, at which places slight flaws are not apt to have any serious influence on the performance of the rail. There is also in use a process for removing the defective surface before the rails are put through the finishing passes.

Although seams are produced in the rolling, still the amount of harm they do is largely dependent on the design of the rail base. Wide thin bases are much weakened by seams in the bottom, while thick bases with large fillets between the web and the base are much more resistant to their weakening effect.

To make rail metal free from slag is mostly a matter of skillful furnace practice, and to avoid harmful amounts of manganese sulphide the sulphur should be kept low. Although these non-metallic inclusions do not ordinarily much influence the longitudinal properties, unless present in large amounts, they may, however, be the cause of rail failures in track by lowering the transverse properties of the rail metal.

Brittleness One of Main Causes for Rail Failures.—For convenience, brittleness may be classified as follows:

- Brittleness in rails ....
  - Head brittleness.
    - Due to interior segregation
    - Due to interior cracks
    - Due to non-metallic inclusions
  - Base brittleness..
    - Due to interior segregation
    - Due to seam in bottom of base

Brittleness is one of the main causes for rail failures, and every effort should therefore be made to obtain ductile metal in rails; the ductility should be both longitudinal and transverse. There has been a progressive decrease in the number of rail failures of the country as shown by the records of the American Railway Engineering Association since the association has compiled general rail failure statistics, except that during the recent World War there was a halt in the improvement. During this period the difficulties both in the manufacture of the rails and their care in the track were of course great, but from now on, however, it should again be the ambition of the steel and transportation industries to continue the improvement in the performance of the rails. According to the 1913 report of rail failure statistics, there were about 400 failures per 100 track miles after five years' service as an average for the whole country. According to the last or 1918 report, the rails rolled in 1913 gave about 100 failures per 100 track miles, after five years' service. This was one-fourth the number of failures and we may well feel elated over the good showing. Although the records of the recently rolled rail are not starting out well, it should be the endeavor of us all to make another 75 per cent reduction in the failures of the rails to be rolled in the future.

The Perforating Process for Timber Treatment

At the February meeting of the American Wood Preservers' Association at Chicago, Mr. Edmund M. Blake, of San Francisco, read a paper on the perforating process for treating railroad ties and other timber. Reference to this process has already been made in recent numbers of Engineering and Contracting.

Mr. Blake stated that it is a process that will apply to the heartwood of any timber which ordinarily resists satisfactory penetration of preservative.

Perforating can also be used on round tapering sticks, such as poles and piling, and studies have already been started on the design of machinery to accomplish this purpose with timbers of that shape. Its application to structural timbers for use in bridges and other structures, in which the beams are subjected to loading in tension or shear, can only be settled after thorough investigation of the effect of the perforating holes upon the tensile and shearing strength of the timber.

The paper concludes with a summary of the claims made for this process, as follows:

The control, reduction, or complete elimination of checking in green ties and timber if perforating is done promptly after cutting.

A reduction of the temperatures required to secure satisfactory impregnation.

A reduction of the time required to treat ties and timber in the retorts.

A complete and uniform penetration of the preservative to the depth of the perforations.

A reduction of not over 8 to 10 per cent in the strength of the timber in compression perpendicular to the grain.

A reduction of the loss in the strength and mechanical life of the treated unperforated ties or timber to a point which will balance the cost of treatment to the satisfaction of the demands of track maintenance engineers.

Some First Hand Information on Public Utility Operation by Seattle

Some months ago Seattle, Wash., bought the local street railway system. What were the results?

Were the rates cut?

Could the city operate a public utility more cheaply?

Was there better service?

Could efficiency of employes be maintained?

Could "brains" be attracted to a municipal venture?

Were public utility affairs taken out of politics?

The answers to these questions were given by Ole Hansen, Mayor of Seattle, when the car lines were purchased, in an address delivered last month before the New England Association of Gas Engineers. The address practically in full, follows:

Our city 20 years ago had 83,000 people. In 10 years we had grown to 240,000. Our population is now about 350,000 to 400,000.

Some years ago the Stone & Webster people consolidated our street car lines in the city of Seattle. They also developed large water power for the production of electric light, having one of the most economical developments in the White River that I know of in this country.

From the time of the installation of the first street railway in Seattle, there had been continuous trouble. I do not know who was to blame. I think all sides were to blame.

When the light plant was established, about 15 years ago, the city of Seattle started to produce its electric light and power in a small way, having but one hydro installation, which produces a maximum of 9,500 Kw. We used the municipal light plant in the endeavor, as the citizens thought, to secure a fair rate from the electric company, which sold and produced a great deal of energy.

When I became mayor, I believed that the only outcome of the agitation in relation to street railways, and probably electric power, was municipal ownership. I had come to the belief that the public was so prejudiced against public utility corporations that it would not give them a square deal; that the end of the investment in public utilities from the private standpoint had passed. I served as mayor for 18 months.

Efficiency and Fairness of City Charges.—When I became mayor I desired to investigate and understand as well as I could the working of our electric light plant, and I found that we had a fairly good installation, though more or less temporary. I found that we had added to the hydro a steam plant.

I came to believe that we were not as efficient or as fair in our charges and in our working of our municipal utilities as we could be.

I found that, for instance, where we installed perhaps a million dollars' worth of wartime connections—purely temporary—that instead of charging these installations to the consumers, that we sold the electric energy sometimes at less than the average cost of production, and added to plant account the investment which any sound thinking man would agree should have been charged off in increased rates in three or four years.

We charged from ½ ct. to 5½ cts. a kilowatt for our energy. We had been giving away our carbon light. I did not know why—because the carbon light, as I was informed, cost the consumer a great deal more. I wrote a letter to the superintendent of the light department and ordered him to discontinue the giving away of the carbon lights. We were giving away $40,000 worth of these lights a year to the consumers, and I do not know how much the increased cost was to those who accepted our "free carbon" bulbs. Well, we saved $75,000 or $80,000 that way.

There was a continual struggle to cut the rates below the actual cost. Men became candidates for office with no other issue than the fact that they were for municipal ownership, but

When the time came to take care of the utilities in a business way—because in the final analysis the man that burns the light must pay for the light, that is all there is to it, and that is the taxpayer—when the time came they were always found on the side of cutting the rate to the man that used the power or light, and by some camouflage or other, by bookkeeping or otherwise, apparently showing a profit.

Street Railway Had Been Making 2½ Per Cent.—The time came when the Stone & Webster people, who operated our street car lines, could not operate at the 5 ct. fare.

I did not know a great deal about the street car business, but I did know enough to get men who did know, and we had access to the books of the company.

We found that the company over a period of several years had made an average of but 2¾ per cent on their street railway business, and that in spite of the fact that they carried the cost of the energy, which they purchased from themselves, at almost nothing; at very much less than the cost. The state law said that they could not charge more than 5 ct. The men were working at the old scale of wages. The government came to the city of Seattle and demanded service to the shipyards.

There was no way that the company could give the service—could even secure the money to make the necessary developments. On their last loan of $12,000,000, I was informed that they paid 9¼ per cent interest to secure that loan, to take up old bonds. Mr. Taylor, the head of the transportation department, came out. There was a great demand for the service to the shipyards. The people demanded more service. The company was unable to at that price give service. We could not, if we would, lawfully grant them an increase of fare.

Finally we made the company a proposition to lease the street car lines for a period of years at the average of what they had earned the previous 5 years. Of course, I was representing the city; in other words, I was the manager for the city of Seattle, as you might say. Well, the company allowed us to go through their books, and we began at the first day the first excavation was made and the first tie and rail laid, and we carefully and conscientiously chose the accountant that the municipal ownership advocates in the council wanted to be chosen.

We fonnd that the street car lines in the city of Seattle had cost—actually cost, without any camouflage, without any bunk, without any water—in money $15,000,000.

The Course Taken.—There were three courses open to me as mayor.

One was to drive this company to the wall, practically confiscate the investment in their lines; the other was to pay reproduction cost; or, on the other hand, go to the company with a proposition that we would pay them for their lines the money that they had actually invested.

I decided that I did not have to steal for the city of Seattle, any more than I would have stolen for myself in a private capacity.

We offered them $15,000,000 in bonds on 20 years' time, installments beginning after the third year, at 5 per cent interest, for their street car holdings. It had proven an unprofitable enterprise. It had become more and more unprofitable as the resentment of the people increased. We then submitted the purchase to a vote of the people. They purchased the street car line by a vote of 4½ to 1. The Puget Sound accepted the $15,000,000 worth of bonds.

I previously had appointed a man to take charge of our little municipal street car line, which was already operating. He was an energetic, honest, courageous man and a close student. We secured as many of the Stone & Webster men as we could and went to work operating the street car line. The operation of the street car line was successful. We found it cost $2.40 an hour to operate a street car, figuring everything, on our streets. We put on more street cars and gave from 1,000 to 1,500 hours more daily service. We increased our income, but on account of the increase in wages made necessary on account of the increased cost of living, it was hard sledding.

Should Have Increased Fares.—The right thing to have done, the thing I wanted to do, was to have the public pay a sufficient increase commensurate with the cost of hauling, especially as we had to reduce the principal and pay the interest.

We entered into a contract to buy the energy necessary from the Puget Sound Electric Co., stepping down, as we wished, 5,000 KW. after the third year. Our figures showed us that it would cost something like $750,000 per year for energy to run the street car line at 1 ct. per kilowatt on the far side of the transformer, and that was a reasonable price, we thought. We put on the street cars little testing arrangements whereby each motorman received a prize for using less energy on his run, and we were able to cut that expense very materially—I think, something like $150,000 a year. We, of course, used the city's legal force at the taxpayers' expense for all suits. All the departments did it.

The company would come into court with a damage suit, and the verdict would be $5,000; we would go into court with a damage suit and the verdict would be $500. They could sue the company under our laws at any time within three years; under our laws they had to begin suit against the city within 30 days, or they were out of the court. We did everything possible, speeding up the cars almost to the danger point, to make the street car lines pay.

Employes of City Wouldn't Work.—The street car men, believing that they owned the street car lines, made a demand at one time that unless we granted their demands they would strike. I called their leaders into the office and told them it would please us very much if they would strike. They talked strike—we had raised their pay from 35 to 40 cents an hour to over 60 cents, I believe—and I asked them for God's sake to strike, so that we would get rid of some of the poor men. Under the civil service we could not discharge them. Well, they did not strike.

The city superintendent of utilities, who took charge of the street car lines, worked 20 hours a day, as did other men interested in the street car business. We did everything possible.

The Public Utility and Politics.—But just as soon as the primaries began to get near, men became candidates for the office of councilman, and for the office of mayor, and in every community where they spoke they promised extensions, promised to force through extensions when there was no reason for the extension and no way in God's world, at any rate of fare, where the municipal street car line could even carry the interest charges ou the extension.

Instead of taking the public utility out of politics, it became at once the football of politics.

Whenever a man in overalls made a demand it was almost impossible to keep him at the scale of the man in private employment, hardly possible; but the city would only pay the head of that street car line, representing an investment in total of something like $17,000,000 or $18,000,000, $4,500 per year.

The result, of course, would be that as soon as a man was trained and became efficient in charge of any municipal utility, some private company would step in and take the brains away from us.

I have come to the conclusion that there is but one way to operate the great public utilities and railroads of this country, and that is that the public must be so educated to understand exactly what the public utilities are up against and must be taught to be fair.

Municipal Ventures Could Not Hold "Brains."—I think every advantage should be given for the conduct of private enterprise and it should be allowed to remain in private hands.

I think that whatever economies a government running a railroad is allowed to make, whatever correlation or combination the government, for instance, has made which has brought about savings in the government operation of railroads, the private companies should have the right to correlate, to combine and to operate.

I believe that with public encouragement we can get our public utilities operated properly. I believe, on the other hand, that the public must be protected from extortion and from poor service.

But I cannot believe, from my experience, that the public utility that employs any large number of men, or where a large amount of capital is necessary, can or will function as efficiently as a publicly operated utility as a private corporation which has individual reward at the end of the day.

Nor do I believe that the cities of this nation or the government of this nation will ever be willing to pay for brains.

Brains are the cheapest thing there is in government, and your are driving the men of brains away because of poor recompense. When you do get brains, you cannot keep it. I think that is the main fault with our government ownership and municipal ownership.

I do not believe the men of the utility business have told the facts of their business in one and two-syllable words to the public.

Everybody, for instance, believes that the gas companies make a lot of money.

You and I know that the gas companies and all the public utilities have been fighting for their lives during this period of increased costs.

Of course the street car lines have a "sacred fare" and you must not interfere with that 5-cent piece. It might have been three, or it might have been six, but it is five, and the moment you raise that fare from the sacred nickel to 6 or 7 ct., or whatever is necessary, the public apparently reacts, and from statements that I have received, a raise in the fare very often does not bring a proportionate raise in the amount of receipts.

Public Utility Commissions Influenced by Prejudice.—Before the war the prejudice of the people had been so inflamed against the railroads that the very bodies who were supposed to be above prejudice refused in many instances to grant the railroads of this country commensurate rates.

From my experience in traveling over their country, after the government has had the roads and operated them, I believe that it will take perhaps 15 years to rehabilitate the railroads of this country.

I know whole systems where there is not a single train that even tries—that dares try—to make the slow schedule on which they are running.

I can show you abandoned and unrepaired cars, or cars in need of repairs, on the sidetracks all over the West.

Now, it will take billions of dollars and it will take 10 or 15 years of time before our transportation system is in the condition to function with our growing industries.

Must Educate Public to Truth.—It seems to me it should be the work of every honest man, whether he is in the utility business or whether he is just a man like myself, that has no particular interest to serve, to educate the public to the truth.

The truth is that the railroads have been starved. That is the truth.

The truth is that under government ownership their repairs have not been kept up.

The truth is that under government ownership railroad help is not as efficient. It is not.

I saw in Dallas a train made up to go to Texarkana. Each man had a separate job, I presume, but we waited one hour and forty-five minutes for the mail to be loaded in the mail car, while 16 men in that station, connected with the railroads of this country, in overalls, stood idle and watched one man load that car.

The time has come, it seems to me, to speak plainly. It is no use pussyfooting any longer.

The time has come when we have got to come right out and tell the truth to the people and let them understand that the United States Government is not a self-perpetuating Christmas tree for the benefit of anyone!

The Rights of Investors.—During the war that was all right; it was necessary to do these things; but the time has come now, it seems to me, to stand by and see that the investors get a run for their money.

It seems to me that the time has come to protect that great body of men and women who put their money in public utilities, and who during this war have had their entire capital cut in two, and you have never heard a murmur from them.

The man who invested $10,000 in a railroad bond seven or eight years ago, or five or six years ago, simply has $5,000, figuring on the meat and clothing and house rent basis.

We must see to it, if we are honorable men, that those men get a run for their money, or else we are thieves.

If we want to make the American government a kind of pickpocket, the way to do is just to confiscate these great properties throughout the country.

If after a time it becomes impossible for a utility enterprise that has honestly and conscientiously expended the public's money in creating or developing or building a gas plant or an electric plant or a street car plant—if the time comes that they cannot operate, it is impossible for them to get by—there is only one way; we must raise the rate so that they get by, or we must refund to them the money they put in the enterprise.

Of course I know what these little spittoon philosophers in every town say about all corporations, but in the final analysis the corporations are owned by the great rank and file of the people, who have been thrifty enough to lay aside something for a rainy day, and I believe that every public man's work in this country is to see that those men get justice and at the same time see that the public gets adequate service, rendered at a fair price and compensatory remuneration.

Methods and Costs of Constructing Tunnel for Heating and Power Lines

Several years ago a tunnel about 1,200 ft. long was constructed from the power plant on the campus of the University of Colorado, Boulder, Colo., to the northwest corner of the old engineering building. This tunnel carries steam mains and returns for heating the buildings and electric lines for light and power.

During the summer of 1919 the tunnel system was practically doubled in length by the addition of 1,217 ft. of tunnel. The location of the old and new tunnels is shown in Fig. 1a. The tunnel extension was designed by W. C. Huntington, Professor of Civil Engineering, and W. E. Brockway, Instructor in Civil Engineering, of the University of Colorado, and was constructed by force account under their direction. The work is described by Messrs. Huntington and Brockway, in Vol. XVI, No. 1, of the University of Colorado Journal of Engineering, from which the matter in this article is abstracted.

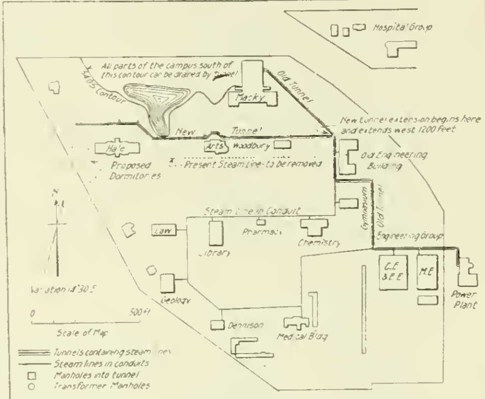


FIG. 1a MAP OF CAMPUS SHOWING HEATING SYSTEM

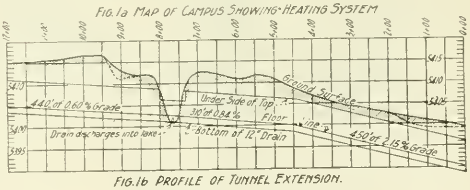


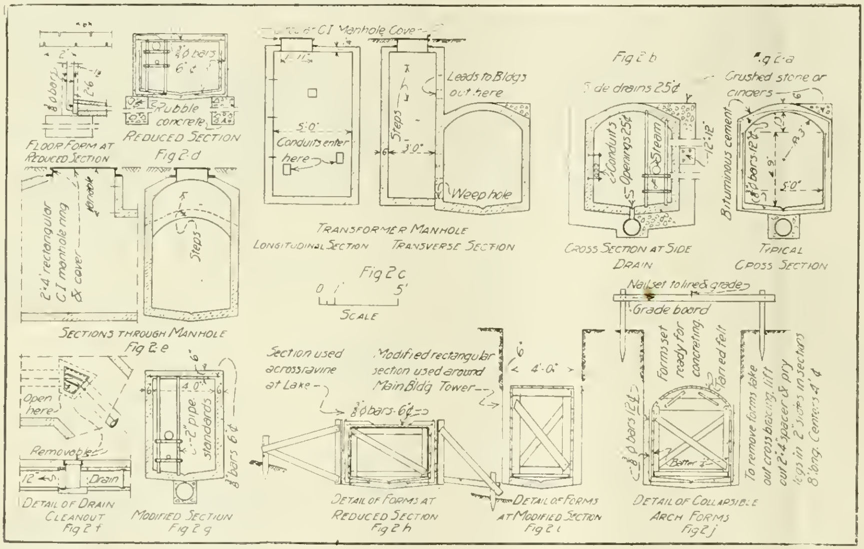
FIG. 1b PROFILE OF TUNNEL EXTENSION.

Figs. 1a and 1b—Map Showing Location of Tunnel and Profile.

The Old Tunnel.—The old tunel was built in 1909. The form of cross section is shown in Fig. 2a. It was not reinforced, the roof was not waterproofed and the drain under the floor was only 6 in. in diameter. For these reasons the tunnel has been unsatisfactory on account of cracking, leaking of the roof and insufficient drainage capacity. It is, however, serving its purpose fairly well, and except for one section will probably never need to be replaced. The section which will have to be replaced at an early date is near the east end. Here the part of the tunnel section rested on filled ground which has since settled, causing dangerous cracks. Its condition would have been much better today if reinforcement had been provided, but even then cracking would doubtless have occurred unless precautions had been taken to prevent settlement. The 6-in. drain under the floor should be taken up and a 12-in. drain provided.

General Features of the New Tunnel.—The location adopted for the new tunnel has the advantage of being 6 ft. lower at the west end for the same amount of excavation, making it possible to carry the returns from the steam lines from practically any part of the campus without pumping. The elevation of the bottom of the tunnel at the west end is 5,405 ft. above sea level. This contour is shown in Fig. 1.

The cross-section of the new part of the tunnel is the same as that of the old part with the exception of the drain. Vertical reinforcement consisting of ⅜-in. round rods 12-in. c. to c. is provided. This is placed in the proper positions to resist tensile stresses which will be developed by the pressure of the surrounding earth. Light longitudinal reinforcement is provided. The cross-section is shown in Figs. 2a and 2b. This cross section was used for all of the tunnel except the offset in front of the Arts Building and the section crossing the ravine. In the first case the section was made rectangular with an inside width of 4 ft. and a height of 6 ft. (See Fig. 2g.) It was considered desirable to obstruct the ravine south of the lake as little as possible on account of its natural beauty. For this reason the height of the tunnel was reduced to 3 ft. 2 in. inside with the width remaining 5 ft. as before. The section was made rectangular as shown in Fig. 2d. Considering the usefulness of the tunnel it would have been much preferable to have continued the tunnel over the ravine, using the same section as that in the remainder of the tunnel.



Figs. 2a to 2j—Typical Cross Sections of Old and New Tunnels and Detail of Construction Features.

The steam lines and electrical conduits are supported as shown in Fig. 2b. Transformer rooms have been supplied beside the tunnel for each building so that the transformers could be kept out of the buildings. (See Fig. 2c.) Manholes are provided at intervals so that pipe and other material can be placed in the tunnel or removed. (See Fig 2e.) These manhole covers are 2 ft. wide and 4 ft. long with their long axis on the center line of the tunnel. Small lateral rooms 2 ft. x 3 ft. were provided for steam valves where steam lines branch off to buildings.

To reduce trouble from ground water to a minimum, 2 12-in. vitrified pipe was laid with open joints in crushed rock underneath the floor of the tunnel as shown in Figs. 2a, 2b and 2f. Vertical side drains 12 in. square, spaced 25 ft. apart, dug in the earth banks, were filled with crushed rocks and connected to the bottom drain. A layer of crushed rock was placed on top of the roof. With this provision for drainage it is expected that no trouble will be experienced with water. (See Fig. 2b.) To make certain that no leakage occurred in the roof the top surface of the roof was mopped with bituminous cement.

Excavation Methods.—The excavation of the trench was started on June 30. This work was let by contract. The remainder of the work was done by force account by the University. The contract called for the excavation of a trench [illegible] ft. wide and varying from 8 ft. to 13½ ft. deep, and for a sub-trench for the 12-in. vitrified pipe drain (see Fig. 2a) in the bottom of the main trench about 16 in. deep and 18 in. wide. The trench was excavated by teams with plow and wheelers to the entire depth. Hand trimmers followed the teams and brought the sides and bottom to the true line and grade. Turnouts were left for the teams about every 200 ft. These were later removed by hand. The sub-trench was excavated by hand. From Sta. 0 + 00 to the lake ground-water appeared about the level of the bottom of the main trench, giving very little trouble, but from the lake west to Sta. 12 + 00 it appeared several feet higher and made team work very difficult. The soil east of the lake was mostly a hard sandy clay mixed with boulders, and from the lake west was a stiff mucky clay to a depth of several feet and a very hard shaley clay below. Some difficulty was experienced in the sandy, rocky clay in keeping the banks true. The double-trees would knock the rock and soil from the banks when the teams passed. In the clay soil, however, the banks stood smooth and true.

The excavation of the offset around the tower of Arts Building (see map, Fig. 1a) was not included in the contract and was all hand work done by force account. The unit cost of this work is given separate from other excavation.

There was no caving of the banks during the entire job in spite of the fact that an unusually heavy rain occurred, filling several hundred feet of the trench full of water at a time when it was not shored and was opened up to a depth of from 8 to 9 ft.

Cross frames were set at each 50-ft. Sta. for line and grade. The grade boards were set with a level and nails placed to mark the center line. (See Fig. 2j.) From the line stretched over the grade boards the measurements were taken for trimming the trench, laying the tile, and setting the floor and tunnel forms. The lines were set at the beginning of the excavation and were not disturbed until the tunnel forms were complete in place. A crew of from 3 to 5 teams and from 4 to 10 men were used by the contractor on the excavation.

As soon as a section of the trench was completed by the contractor the University force began shoring the banks and laying the 12-in. drain. A single course of shoring was placed in the trench to prevent caving of the banks. This proved very effective for that purpose.

Drain Tile and Side Drains.—The drain was laid with open joints and surrounded by crushed rock (see Fig. 2b). At all angles an opening into the tunnel was left for cleaning in case of stoppage. (See Fig 2f.) The pipe was laid so that the top of the bells were 6 in. below floor grade.

The trenches in the side of the main trench for the crushed rock side drains were excavated before the 12-in. drain was laid. (See Fig. 2b.)

Forms.—The U-shaped steel for the bottom and sides (see Fig 2a) was assembled in the trench before the floor forms were set. (See Fig. 4.) The cross pieces, shaped to fit to finished floor, were placed from 8 ft. to 10 ft. c. c. The 2x4's placed longitudinally at each side served to hold the steel in place and to make a square shoulder against which the side walls, which were concreted at a later time, could bear.

The side and arch forms were collapsible and made in 8-ft. sections. (See details, Fig. 2j.) They were set after the concrete floor had hardened sufficiently to prevent damage. The sides were toe-nailed to the legs of the arch center only enough to keep them in place. The 2x4's over the arch were not nailed. The top forms were covered with tar paper which was placed crosswise and allowed to extend down over the sides about 2 ft. on each side. This paper stuck fast to the concrete after the forms were removed, made a smooth surface on the inside top of the tunnel, kept the form lumber clean and dry and will prevent the collection of moisture on the roof of the tunnel when the inside surface becomes warm.

To prevent binding during the removal of the forms the legs of the arch centers were spread about ½ in. at the bottom. (See Fig. 2j.) This allowed the centers to drop down when the legs were pried in and folded up. No difficulty was experienced in removing forms, and the same forms were used over and over without damaging them to any extent. Enough forms to set 200 ft. of tunnel were made and all set in place before any concreting was done. Since this was enough for about four days' concreting the carpenters were able to collapse the forms the second day after the concrete was placed, and move them forward. Very little delay in concreting was caused by the forms not being ready. One carpenter and a helper worked full time on the forms. Common laborers moved the form work ahead in the trench after it had been collapsed. In case there was form work in the trench ahead of the section to be moved up the forms were taken out through the manholes and moved ahead on the surface.

The forms for the rectangular sections around Arts Building tower and across the ravine leading into the lake were not made collapsible as there was but a short section in each case. The lumber used in the forms, after having been used and reset six times, was in very good condition when the work was completed and has a high salvage value.

Sand and Crushed Rock for Concrete.—The sand used in the concrete was obtained from two sources. Before concreting was started enough sand was stored on the ground to build about 300 ft. of the tunnel. This was obtained from a sand pit owned by the university in the creek bottom near the campus. It was a very good grade of sand, but the supply gave out and no additional supply seemed available. A heavy rain, in which nearly 5 in. of water fell in a few hours, solved the sand problem effectively, at a very convenient time. This storm washed a large amount of material into Boulder Creek from the mountains above Boulder. The larger material was deposited near where it came into the creek, but sand was carried down and deposited in the creek bottom through town to a depth of several feet. This sand, as would be expected, was thoroughly washed by the stream and was rather coarse. It was not mixed with gravel and required no screening. The university obtained permission to use a small tract of land bordering the creek at Sixth St. Sand was scraped out of the creek with wheel scrapers and stored on this ground. It was then hauled as needed. The cost of scraping the sand out and hauling to the work was very moderate.

Rock for the coarse aggregate was crushed in a small crushing plant owned by the university and located on the campus. The rocks used for crushing were mostly granite "nigger heads" gathered up along Boulder Creek and hauled to the crusher. The rock, mostly sandstone taken from the trench in excavating, was also used. The run of crusher stone was elevated and passed over a ¼-in mesh inclined screen and into a bin. The screen removed all fine material. The screenings were mixed with the fine aggregate in known proportions as mentioned above. The crusher used was a 9-in. x 15-in. Blake jaw crusher. A large per cent of the crushed rock was under 2 in. in size. The rock was hauled in dump board wagons from the bin to the work.

Nearly all the lumber used for forms was second hand, having been previously used by the university for concrete form work. In figuring the cost of the work, however, all lumber was taken at current prices for new lumber. This was done so that the cost data would more nearly conform to what the actual cost would have been if all material had been purchased for the job. The cost of the forms given below represents the total cost, no deductions being made for the salvage value of the lumber.

Mixing and Placing Concrete.—The mixer used was a 1-sack batch-mixer. It gave very good satisfaction. During the entire run of 40 days not a cent was spent for repairs and not an hour lost due to mixer trouble.

The floor was concreted first. This was allowed to harden and then the forms were set and the sides and top concreted. Wheelbarrows were used for charging the mixer and for removing the mixed concrete. The mixer was moved for each day's run. No concrete was wheeled farther than 50 ft. The mixer was placed near the trench between a pile of sand and one of crushed rock. Plank run-ways were laid longitudinally on 4-in. x 4-in. crosspieces over the center of the trench and the concrete dumped from them to either side. The ordinary crew used in mixing and placing concrete was:

Sand and cement one man;

Crushed rock—one man if the material was very close to the hopper, but generally two men were necessary;

Operating mixer—one man;

Wheeling concrete—two to four men, depending on the length of the haul, generally three;

Spading and finishing—Foreman and one finisher, who also placed the bolts for carrying electric conduit in the forms, cut the holes for pipe standards, and placed the top reinforcing steel.

Each batch of concrete made four wheelbarrow loads. When three men were wheeling, the first man to load would be back ready to empty the mixer when the third man got out of the way. One hundred feet of floor was concreted at each run. The actual concreting took until noon. In the afternoon all of the crew except the finisher, one man to operate the mixer, and one helper would be used at other work. The three men would put on the finish coat and prepare for the next day's run. When concreting the sides and top, 50 ft. were run each day. A finish coat was put on the top to give a good surface upon which to apply the waterproofing. Both the floor and top were float finished. The first concrete was placed Aug. 12, and the last on Oct. 18. This does not represent the actual time of concreting, however, as several times the entire force was taken off to do other work, and stormy weather caused some delay.

Waterproofing and Backfilling.—The outside top surface of the arch was coated with one heavy coat of bituminous cement, applied hot. The cement was melted in a kettle and applied with old brooms. At construction joints tar paper was imbedded in the hot cement and coated over.

After the waterproofing was completed the side drains were filled with crushed rock and the crushed rock placed on top of the tunnel as shown in Fig. 2b. About 6 in. of dirt was then placed over the top by hand. The balance of the back filling was done by teams and scrapers. The hand work was done to protect the waterproofing from the scrapers and horses' hoofs. At the time the trench was excavated, enough dirt was left on bank for the back filling.

The cost of the work is shown in the following table:

Item.	Unit cost.
Excavation, 2,704 cu. yd.	$ 1.21
Backfilling, *727 cu. yd.	.35
Cement, 2,261 sacks	.75
Sand, 295 cu. yd.	1.28
Crushed rock, 462 cu. yd.	1.84
Tile drains, 1,265 ft.	.52
Forms,† 26,981 sq. ft.*†	.05
Steel, 147.8 cwt.	4.74
Assembling and placing steel, 7.39 ton	18.65**
Shoring, 1,000 lin. ft. of tunnel	.27
Waterproofing top, 1,690 sq. yd., covered††	.10
Mixing and placing concrete, 537 cu. yd., placed	1.78
	Total cost.
Engineering	$ 238.60
Superintendence	331.29
Miscellaneous	502.96
Manhole covers	132.51
Total	$12,688.82

Feet of tunnel, 1,217; total unit cost, $10.48.

*Estimated. †All lumber considered as new. Most of it, however, was second-hand. *†Square feet of inside surface. **Includes bending. ††One heavy coat.

In addition to the above cost there was an item of $63.71 for moving water pipes from the trench, and $235.06 for removing sewer pipes. These items are not part of the actual construction cost. The wages paid were as follows:

	Per hour.
Carpenter	$0.87½
Concrete foreman	.75
Finisher	.62½
Skilled labor	.50
Unskilled labor	.43¾
Teams	.87½

The following table gives the cost of concrete in place per cubic yard. In all 537 cu. yd. of 1:2¼:3¾ concrete were placed.

Item.	Total cost.	Cost per cu. yd. concrete.
Cement	$2,445.75	$4.56
Sand	376.25	.70
Crushed rock	848.56	1.57
Mixing and placing concrete	953.91	1.77
Superintendence	166.00*	.31
Miscellaneous	251.50*	.47
Total	$5,041.97	$9.38

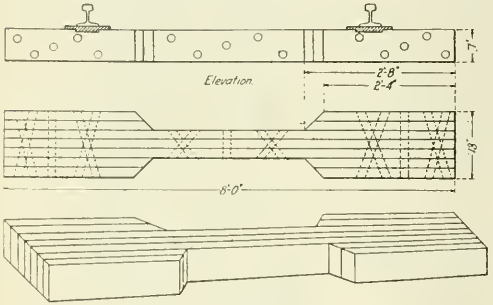
*Taken as half of total.

This cost of $9.38 per cubic yard does not include forms. If forms were included it would make the cost per cubic yard $11.97.

A Laminated Wood Cross-Tie

In an attempt to conserve timber in cross ties, a recent development is a sectional or laminated tie made by the Revert Sectional Tie Company, of Reno, Nev. This tie is well shown in the accompanying illustration, reproduced from Railway Age with the following description:

The main body of the tie is made up of three pieces of 2-in. by 8-in. surfaced lumber 8 ft. long, which are reinforced at each end by four pieces of similar material of the same width and thickness. These pieces are placed two on a side and are 28 in. and 32 in. long, respectively, the ends toward the center having a 1 to 1 mitre. The maximum width of the tie thus constructed from 2-in. stock is approximately 13 in. and the minimum about 6 in., the mitred end pieces forming a tapered shoulder at each end and on both sides. After being cut to shape, each piece is treated with a preservative to insure a uniform penetration in the tie when it is completely assembled.



Sketch Showing Arrangement of Dowel Pins, Etc.

After the treatment, the parts of the tie are assembled, held in clamps under heavy pressure and 15 1-in. wooden dowels inserted to bind the pieces firmly together as a unit, 12 being driven on a diagonal and three straight across as shown in the illustration. A special tie-plate is used which overlaps the edges and further assists in holding the parts, besides furnishing a larger bearing surface for the rail.

A comparison of the lumber in the Revert tie with the amount in a 7-in. by 10-in. by 8-ft. one-piece tie shows a saving of approximately 5,000 b.m. ft. per mile of track and an increased rail bearing surface of about 333 lineal ft. per mile. The tie is now being tested by the Southern Pacific on a section of line near Reno, following its use over a number of years on the logging railroad of the Verdi Lumber Co., where it was subjected to heavy rains, snows and frosts with satisfactory results, and without any separation of the pieces composing the tie.

Railroad Construction in Last 20 Years.—Interesting information on the mileage of railroad constructed in the last 20 years was given in a statement issued early this month by the Association of Railway Executives. The figures follow:

Year.	Mileage.	Year.	Mileage.
1900	1,894	1910	4,122
1901	5,368	1911	3,066
1902	6,026	1912	2,997
1903	5,652	1913	3,071
1904	3,832	1914	1,532
1905	4,388	1915	933
1906	5,623	1916	1,098
1907	5,212	1917	979
1908	3,214	1918	722
1909	3,718	1919	686

Screw Spikes on Electric Railways

Experience with screw spikes on steam railroads has been quite extensive, but the conclusions arrived at by railway engineers with regard to the merits of the screw spike have not been unanimous. Coincident with their introduction on steam railways screw spikes began to be used on some electric railways; and here too the opinion seems to be not all in favor of their use.

Mr. W. W. Wysor, Chief Engineer United Railways, Baltimore, writing in the Electric Railway Journal, has the following to say regarding the use of screw spikes on the lines over which he has supervision:

For a number of years past, in the city of Baltimore, screw spikes have been used as standard construction on all girder rail, with the exception of special work, but there does not seem to be any logical reason for having done so nor for continuing this practice.

When the question was asked: "Why use screw spikes?" the answer generally was, "Because they hold better," or the more indefinite one, "Because it is better practice or in line with more up-to-date methods." There is no doubt that screw spikes, when newly driven, require more force to withdraw them than do nail spikes, but when ties decay or spikes for any reason become loose, the greater holding power of the screw spike is lost. Moreover, if the lifting force exerted on nail spikes is not sufficient to withdraw or loosen them, why go to the expense of providing a spike of greater holding power? The functions of a spike are to hold the rail to gage and prevent overturning, and there is every evidence, so far as the observations of the writer go, that this is performed by the nail spike equally as well as by the screw spike, at least in street railway tracks.

In the last few years we have reconstructed in the city of Baltimore many miles of track which had been down for periods ranging from 10 to 25 years and which had been laid with nail spikes. In every case where ties were solid, the spikes were found in place as originally driven, and it required as much or more force to withdraw them than it did newly driven spikes. In the case of rotten ties, of course any form of spike is valueless.

About two years ago we started keeping a record of the cost of screw spikes as compared with nail spikes and found that the former cost about $1,500 per mile more than the latter, without any apparent benefit.

In order to determine what the various roads were doing, a questionnaire was prepared and forwarded to 48 of the most prominent street railways in the country. Replies were received from 3 companies—a list of the questions and a resume of the answers received being shown in the following statement. It will be noted that a majority of the companies do not use screw spikes and most of the companies that do employ them use them only in particular cases, such as for bridge and subway work. For this kind of work, where traffic is very heavy and where the rails wear out long before it is necessary to renew the ties, the use of screw spikes may be justified, inasmuch as they can be withdrawn and redriven with less damage to the ties; but for ordinary construction in paved streets, not a single valid reason has been given for their use.

When screw spikes were first adopted on this property, tie plates were adopted at the same time, and it seems probable that this was true of other properties, not only of street railways but steam roads, and the better results that have been obtained from this type of construction were, in my opinion, due entirely to the tie plate and not to the screw spike. After a very careful consideration of the matter, this company has abandoned the use of screw spikes but has retained the tie plate. We believe the tie plate to be well worth its cost.

RESULTS OF QUESTIONNAIRE ON SCREW SPIKES.

Question No. 1—Do you use screw spikes? Answers: Four companies answered "yes"; ten companies, "to a limited extent only"; twenty-two companies, "no."

Question No. 2—Are they employed as standard construction in (1) city streets? (2) on interurban T-rail tracks? (3) on special construction such as subways, elevated structures, etc.? Answers: (1) Four companies answered "yes"; nine companies, "no." (2) Fourteen companies answered "no." (3) Eleven companies answered "yes" and three "no."

Question No. 3—On what sections of rail are they used? Answers: Eight companies answered "standard T-rail"; six, "high T-rail (Shanghai)"; seven companies, "girder rail."

Question No. 4—Do you use tie plates with screw spikes? If so, are they specially formed so as to give support to the head of the spikes? If not, do you use a clip? Answers: Five companies replied they did not use tie plates; three companies that they used plain plates; three that they used special plates and three that they used combination plates and clips.

Question No. 5—What considerations led you to adopt the screw spike? Answers: Three companies replied "increased holding power"; four, "special construction, such as subways and bridges and where more or less permanent foundation is employed and where rails can be renewed without disturbing the foundation"; two, "expcrimental only"; one, "best type of fastening"; one, "used with tie plates to prevent cutting of ties"; one, "on account of decreased maintenance of special work"; one, "seemed to be in accordance with best practice."

Question No. 6—Has it met with your expectations and proved satisfactory in service? Answers: Three replied "yes"; one, "no"; three, "experimental only"; seven, "yes for special purposes for which they are applied."

Question No. 7—In comparing the performance of screw spikes as against nail spikes, are tie plates employed in both cases? Answers. Seven companies replied "yes"; seven, "no"; four, "no comparisons made."

Question No. 8—What is the excess cost per mile of single track of screw spike construction over nail spike construction? Answers: Ten replied "no data"; one, "double the cost of hook-headed spikes"; one, "$2,422.00"; one, "$1,000.00."

Question No. 9—Do you consider screw-spike construction of sufficient superiority to justify this excess cost? Answers: Four companies said "yes"; five, "no"; three, "yes as limited to special construction"; one, "in hard wood, no; in soft wood, yes."

Subsidence of Embankments

The Committee on Roadway of the American Railway Engineering Association, in its report at the March convention, presented some information on the settlement or subsidence of embankments which should be of interest to engineers. Although not always so understood, subsidence is a matter quite distant from shrinkage. No doubt in many cases what has been observed and referred to as shrinkage was partly subsidence, even in cases where the ground was of such a nature as to give no indication of sinking when loaded with an embankment.

The following is abstracted from the committee's report:

There is apparently more subsidence than has been generally supposed, and until recently it has only been supposed to occur in places where the foundation was known to be of an unstable nature. However, the study made by the committee, covering reports made upon some hundreds of miles of line, indicates that subsidence exists to a greater or less extent under all embankments. Not only was grading material found, but the investigation disclosed quantities of cribbing, mattress work and timber of all kinds, of which no definite record is kept.

The methods usually employed to determine the amount of subsidence are: Trenching; auger borings; wash borings.

Trenching is used only through light embankments and at the toe of larger ones

Auger borings are made in fills where the material is of such a character that the earth auger will penetrate and bring up the material. Usually a protecting pipe casing is driven through the loose material and the auger operated through this pipe.

Wash borings are made when the depth is too great or when the material will not permit the use of the earth auger.

In determining the amount of subsidence, cross-sections are taken at such intervals as is thought necessary by reason of the character of the surface over which the enbankment is constructed, i. e., usually a test hole is made at the shoulder, on the slope and possibly in the center of the embankment; from these tests the surface of the original ground is located and from the notes taken, a cross-section is platted and the yardage calculated in the usual manner.

After the subsidence is calculated in order to determine the equivalent amount of excavation, a percentage (depending on the material), should be added for shrinkage; your committee has found shrinkage in embankments to average approximately 10 per cent.

The committee studied the effect of different sub-soils on subsidence with the object of establishing a relation of subsidence to height of fill; and while the individual cases spread over a wide range, it is interesting to note that the average seems to be 1 per cent subsidence per foot of fill height. Thus a 10-ft. fill would give 10 per cent subsidence, i. e., 10 per cent of the orginal embankment.

When one considers the conditions resulting from operation and the maintenance of track structure, it is apparent that there must be subsidence under all embankments, varying from an infinitesimal amount when founded on solid rock to a very great amount in certain sinks.

In order to find out whether subsidence occurred to any extent under all embankments, one of the roads made an investigation in localities where there was no indication of or reason to believe that there was subsidence, with the surprising result shown in the following table:

	Embankment in cubic yards.			Substance in cubic yards.			
Length in feet.	10 ft. and under.	Over 10 ft. under 20 ft.	20 ft. and over.	10 ft. and under.	Over 10 ft. under 20 ft.	20 ft. and over.	Per cent of increase
1,350		29,599			6,158		20.8
1,570		27,355			8,117		29.7
3,270		93,695			29,669		31.8
1,600	5,161			2,018			38.7
800	7,559			2,752			36.5
6,450		154,031			38,355		24.8
1,225	18,039			13,723			72.5
1,725		37,586			12,062		32.1
2,200	24,224			4,309			17.7
570	3,105			1,382			44.5
4,250	24,098			16,083			66.5
2,010	6,032			5,774			96.0
2,450	30,201			16,073			53.2
3,660	12,415			9,303			74.9
9,500	74,452			38,538			51.6
3,570		77,522			23,450		30.2
1,900	9,608			5,525			57.5
510	9,401			2,169			23.6
3,870	39,790			11,141			27.9
1,380	10,359			2,984			28.7
3,050		55,772			12,021		21.5
1,350		27,611			8,086		21.4
1,260	8,671			2,601			30.0
390	1,271			1,044			82.1
600	2,369			1,558			65.6
840	3,949			2,295			58.0
7,190			284,272	13,602	4,951	32,365	17.8
1,450		12,355			3,813		30.8
1,900	30,195			8,016			26.6
670	755			704			93.3
1,700	5,563			1,009			18.0
1,940		25,796			4,793		18.5
740		17,803			3,441		19.3
1 350		11,869			3,900		32.9
650	1,384			1,156			83.5
620	3,405			616			18.0
750	967			316			32.7
640		7,057			1,919		27.2
425		10,718			5,210		48.6
315	1,935			606			31.3
370	1,633			255			15.8
650	1,741			528			30.3
7,310	34,930			16,284			46.5
170 miles	373,206	588,569	284,272	181,764	165,931	32,365	...
				48.5%	28.2%	11.4%	

The land upon which these embankments were constructed was originally marshy and covered with very heavy loam, but now has been thoroughly drained and the casual observer would have no reason to suspect that subsidence had occurred.

Use of Lag Screws in Trestle Construction

The Committee on Wooden Bridges and Trestles of the American Railway Engineering Association has the following items in its annual report which it recommends for inclusion in the "Manual" of the association:

(a) Lag screws require greater care than ordinary bolts and nuts to properly install, but are cheaper on account of ease of application.

(b) Lag screws, where properly applied, hold ties from bunching equally as well as bolts and nuts, and better than daps, in guard timbers.

(c) If the lag screws are tightened after timber has shrunk, there is less cost of maintenance than with bolts and nuts.

(d) Use of lag screws renders unnecessary the dapping of guard timbers, and, therefore, decreases cost of trestles without impairing quality.

(e) Surfacing (sizing) ties and guard timbers is better construction than dapping; makes a better riding track, thus decreasing impact stresses, and is therefore good practice.

(f) For proper application of lag screws, holes in guard timbers should be bored with auger bits 1/16 in. less in diameter and holes in ties ¼ in. less in diameter than the normal size of lag screws used.

Rapid Decay in Sap Pine-Ties

The following is an extract from a paper on the above subject by Mr. C. O. Deabler, Tie and Timber Agent, at the recent meeting of the American Wood Preservers' Association:

A peculiar point of interest deals with the rapidity with which ties become infected and subsequently decayed. In ordinary seasons a pine tie, when cut during the latter part of the summer, has usually been found to be free from this infection for at least three or four months. There are, of course, always certain individual pieces which are more readily infected, but on the whole, the rate of decay is as just stated. During the latter part of 1919 this rate was much accelerated. A tie in a lot hauled to the tie yard within 24 hours after it was made and there stacked in approved fashion on a well-drained cinder-covered yard showed the small knobs of fruiting bodies on the ends after 93 days.

One point in connection with the life history of this fungus, which it is important to remember in all points of this discussion, is that there is a certain definite period when its presence cannot be recognized by an outside inspection of a piece of timber. The fine microscopic threads are distributed in the interior of the wood and it is only when they have more or less developed to maturity that they reappear on the outside in the shape of the fruiting body. This will explain the fact, for instance, that a great many ties were inspected and pronounced perfectly sound, using the best visual inspection possible, and after having been loaded in box cars where no ventilation was possible, and where the optimum conditions for the development of the fungus were obviously present, such ties showed fruiting bodies on the outside after several weeks in transit and could then easily be detected as infected ties.

We all realize and agree that the sap pine tie is not of a desirable wood compared with the species formerly used by most roads, but the tremendous drain on our hardwood forests, and high prices, brought about by the unusual conditions during the past three years, made it necessary for railroads to consider other than hardwoods. This brought us, naturally, to one of the most available supplies close at home, viz., sap pine. Cross ties were very much in demand and a heavy production was sought in all pine territory. A great deal of this production was in localities where pine cross ties were not formerly produced.

It should also be pointed out that the type of production during the past summer differed considerably from that previously secured, even in sections where pine ties had been produced. In previous years the number of pine ties produced was limited to the minimum quantity needed by the railroads, usually roads in the territory where such ties were produced. This year no limit was put on production and they came out in such vast quantities that by the end of September there were between 3,000,000 and 4,000,000 sap pine cross ties on the right-of-way. This flood, furthermore, was brought about rather suddenly. Due to the absence of rain in the growing season, the corn and cotton crops, on which the farmers in the southwest largely depended, were almost a failure, and farmers naturally turned to tie production as one way of obtaining sufficient money to tide over the winter. This will be readily evident from the figures of the number of ties inspected during July, August, September and October in the southwestern region, which were as follows:

July	1,393,906
August	1,855,822
September	2,624,202
October	2,296,907

While these ties were inspected in the months indicated, a large percentage were probably manufactured several months prior and were not brought to the right-of-way on account of the farming period intervening.

Many of these ties, made as they were by people unfamiliar with pine tie production, were possibly not handled as expeditiously as they should have been in bringing them from the woods to the right-of-way, and a considerable percentage of deterioration probably took place while the ties were still in the hands of producers. But this condition could not be detected until the ties were received.

Attention should also be called to the fact that this very large production took place during a season when wood cut from pine trees was in the best possible condition for rampant infection. It is well known that July, August and September in the South are the worst months for cutting timber from a standpoint of lasting power. These conditions, taken in connection with the extraordinary climatic conditions already mentioned, all contributed to the extensive deterioration which actually occurred.

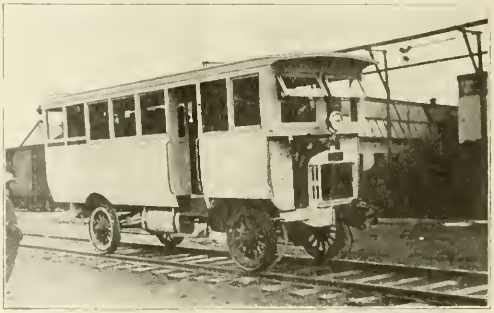
It would be a hard problem to give all the reasons for the deterioration of the sap pine cross ties in the Southwestern region during 1919. Summing up the situation, however, it was brought about largely by the extraordinary climatic conditions, the unlimited production, congested transportation, and the failure of some producers, not familiar with sap pine preservation, to realize the necessity for the ties getting to the right-of-way before infection had taken place. We must realize the sap pine cross tie will be used in larger numbers than ever before, but permit me to caution you as to its care after production. The sap pine cross tie should reach the treating plant as quickly as possible and be treated at the proper time.

The question of arriving at the proper age of cross ties has also been a subject of interest and discussion in the Southwest. Many plants estimate the age of cross ties when arriving at the plant and add to this age the customary time allotted for the proper seasoning, treating the ties at the expiration of this time. This system should be corrected, as ties are received quite frequently at treating plants and carded for some date of treatment when they vary several months in age. This results in some ties being treated too green and others beyond the proper time.

My suggestion is to correct this estimating of the age of ties by the use of the dating hammer as soon as it can be applied, and to separate the ties at the treating plant. This may prove expensive handling, but it will pay in the treating of cross ties before they have gone beyond the treating period. A trip to any treating plant should convince one of this. An advertising campaign among the producers will gradually bring about a wider understanding for this necessity and eventually accomplish very satisfactory results.

Motor Truck Operated on Short Line Railroad

The increasing interest of railroads in the use of motor trucks to facilitate freight and passenger transportation on short hauls is evidenced in the recent addition of motor lines by several railroads. Among these is the Palatine, Lake Zurich & Wauconda Ry., which is using a 3-ton FWD truck, equipped with flanged wheels, and passenger body on its 16-mile track from Wauconda to Palatine, Ill. The truck, which has a capacity to care for 80 passengers, also hauls a trailer loaded with freight and baggage weighing 5 tons. When not pulling a trailer the round trip of 32 miles is stated to be made on 6-gal. of gasoline. The truck is operated continuously from morning until night.



Motor Truck with Flanged Wheels and Passenger Body Operated on Railroad Track.

Where Did the 50 Ct. Come From?—We have just learned of an Engineer who started poor 20 years ago and has retired with the comfortable fortune of $50,000. This money was acquired through industry, economy, conscientious efforts to give full value, indomitable perseverance, and the death of an uncle who left the engineer $49,999.50.—From a Bulletin of the Secretary of the Colorado Engineers' Society.

MANAGEMENT AND OFFICE SYSTEM

This section is published twice a month: (1) In the Waterworks and Hydraulic Monthly issue, and (2) in the Railway and Excavation Monthly issue. It covers what may be broadly termed "management engineering" as applied in the civil engineering and construction fields.

The "Work Unit" in Cost Analysis "Units of Product Per Operator Per Hour!"

How many producers can you name who use such a unit in the study and control of their operations? Not many, according to Mr. L. V. Estes, who explains the method in "Industrial Management" for November, 1919, under the title, "Unit Cost Accounting for Control." The method was worked out by Mr. F. A. Magee, of L. V. Estes, Incorporated; and it appears to possess such decided value for certain classes of production, that we abstract herewith portions of the article mentioned.

"Work Unit" is defined as "Number of units of product per producing agent per hour." The agent may be an operator, a machine, a gang or a group of machines.

"This unit cost is expressed in such terms that it can be directly applied to the actual finished product, eliminating a large amount of detail work consequent upon other methods and at the same time providing the correct basis for:

(a) Determining the operating efficiency.
(b) Scheduling production.
(c) Payment of wage incentives.
(d) Control of manufacturing activities."

Mr. Estes explains the unit and its application by an example from the baking department of a plant manufacturing biscuits and crackers.

When beginning the work of time study it is necessary to prepare, with the help of the foreman, a list of the minimum number of workers required on each machine to process the goods through the operations in question. This list then constitutes the standard gang for the peformance of the operation and it is against this standard gang that the actual number of workers employed each day is checked.

One of the first operations in the baking department is the passing of the goods through the cutting machine. By actual test and observation the standard speed at which this machine must be run to produce the maximum quantity of product of the right quality is determined. The following information is then secured and recorded:

(a) Machine strokes per minute.
(b) Pieces produced per stroke.
(c) Pieces produced per pound of material.
(d) Number of operators required.
(e) Time schedules for a "run."
(f) Standard time required for changing from one "run" to another.

Taking the average figures for a standard soda cracker, we obtain the following as the "work unit":

Strokes per minute	150
Pieces per stroke	6
Pieces per pound	15
Operators on "run"	7
Hours scheduled for "run"	2.5
Standard time to change, minutes	10

Then:

$$\text{Net operating minutes per hour} = \frac{(60 \times 2.5) - 10}{2.5} = 56$$

$$\text{Number of pieces produced per hour} = 6 \times 150 \times 56 = 50{,}400$$

$$\text{Pounds produced per hour} = \frac{50{,}400}{45} = 1{,}120$$

$$\text{Pounds produced per operator per hour} = \frac{1{,}120}{7} = 160$$

Therefore:

160 lb. is equivalent to 1 "work unit."

100 lb. is equivalent to $\frac{100}{160} = 0.625$ "work unit."

As conditions for the performance of any operation will vary in different plants making the same class of goods, the unit that is established by this plan does not represent the same amount of human or machine effort in every case, hence it does not represent a "standard" in the same sense as a pound is standard. It does, however, afford a means for making a quick and intelligent comparison of the results that are being obtained.

The standard of performance having been determined, the figures for each element thereof are entered on a card ruled and headed for the purpose; and thereafter the figures for each run are entered on the same card, together with explanations of any considerable variation from the standard, thus affording a most convenient comparative showing.

In one plant where these methods of cost accounting have been introduced, an increase in production of 25 per cent has been obtained; and this before the plan had been installed two weeks. In another plant, after operating 40 days under this plan, an increase in production of 14 per cent was obtained. In each case the cost of production was proportionately reduced.

The total cost of the production department as taken from the expense analysis, plus the cost of materials used, should agree with the total expenditures as shown by the operating statement, or, the total costs per hundredweight of goods manufactured, as taken from the final cost sheets, applied to the number of pounds produced of each kind of goods, should equal the total expenditures as shown by the operating statement.

Before the installation of these methods in one plant the costing was done on the basis of estimates from "test runs." To handle this work there were required five employes, at a total labor cost of $80 per week. With the introduction of this plan only two employes were required, at a labor cost of $30 per week, a saving of $50 per week for clerical labor.

In addition to this saving, under the new methods actual costs were obtained for every "run" and complete control was made possible.

Truck Maintenance Costs Reduced by Unit System of Repairs

The unit repair system consists of keeping on hand in the garage complete truck units such as engines, gearsets, and rear axles. These units are kept in A-1 shape and ready to be installed at a moment's notice. When a truck is brought into the shop with any one of its units in need of repairs, the damaged unit is removed in its entirety, and one of the units kept on hand put into its place. This holds good with engines, gearsets or rear axles and even with other truck parts such as clutches, brakes, magnetos, wheels, body hoists, etc.

The value of this method, states the Commercial Vehicle, lies in the fact that the truck can be sent out again on the same day to continue its regular work instead of being held up for two or three days while repairs are being made to some one or more parts of the damaged unit. Care must be taken that a sufficient number of units is carried on hand to permit each unit to be put in first class shape before a second truck is liable to be brought in for the substitution of the damaged unit taken from the first truck.

The unit system of repairs requires a considerable investment in spares, but this investment grows proportionately less as the fleet becomes more and more standardized. Then, one unit may serve as a replacement part for as many as from 5 to 10 trucks, depending of course upon the make and size of the trucks and the severity of the work in which engaged.

How a Large Management Association Saves Insurance Premiums for Its Companies*

In insurance we act in a general supervisory capacity, and give advice and help as much as we can. All policies are sent in to us for examination and scrutiny. The insurance policy is a contract between the owner and the insurance company. A good insurance policy is good protection, and a poor insurance policy is no protection at all. For that reason we examine every policy that comes in. In some cases the insurance is placed by the local offices; in other cases it is placed by our office.

I can state in a general way that if the condiiton of our properties was today what it was in 1903, and if the insurance rates were what they were then, we should be paying $475,000 per year more than we now are, and we are getting a great deal better protection today than we were in the beginning. That saving has come from a number of sources, but it has come with the co-operation of the local companies in improving our properties. At one time the feeling seemed to exist that the more an insurance is split up and the greater number of policies we had, the better was the local company's protection, and exactly the reverse was found to be the case. We would give a great deal more for a single policy in a big, strong company than for 25 small policies in 25 strong companies, for the reason that the company writing that single policy attracts the notice of the home office of the company, which sees that the local company gets the best protection.

We place through the home office the boiler insurance, which is placed in the form of a blanket policy, a single policy covering the boilers of all the Stone & Webster companies. The limit of that policy for any one disaster is $50,000. By placing the blanket policy through this office we are able to get that large amount of protection for about 25 per cent less than if every company placed its policy singly.

Another policy of blanket form is that covering the fire insurance of the automobiles of our companies. We cover nearly 400 cars at the present time, and the aggregate value must be from $300,000 to $400,000. By writing the blanket policy at the time we did, we were able to get insurance for much less than we could have gotten it later.

Another matter which we handle is the fidelity bonds of all the companies. The bonds at the present time aggregate $3,000,000. The company which was handling our business a number of years ago was able to make us a special rate for all our business. Taking the time of which we have record, which is from about 1903, the total amount which the insurance company has had to pay over to us is about $25,000, of which the company has been reimbursed about $12,000, which has been paid back by individuals who have taken our money and afterwards compromised with the insurance company. The loss to the insurance company is about $13,000, certainly a wonderful record; a record which is regarded by us with a good deal of pride, and I may say by the insurance company as well.

One question which often comes up in connection with insurance is what the real meaning of the co-insurance clause is. The ordinary form of policy usually carries a co-insurance clause, ordinarily an 80 per cent clause. The proposition is very simple. The insurance company has given a lower rate in consideration of the guarantee that insurance will be carried to 80 per cent of the value of the property, with the penalty that if you do not carry insurance to the amount of 80 per cent, the amount of any loss will be divided between you and the insurance company in proportion. Values and costs have increased so rapidly that it has been necessary to increase the amount of insurance in order fully to comply with the requirements of the co-insurance clause, and it is necessary for every company to study its values carefully and see that it does comply with this co-insurance clause. The local people who are on the property know or can ascertain the value of the property insured better than we can in the Boston office.

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*From a talk by Mr. N. H. Daniels of Stone & Webster to members of the organization. Published in "Stone & Webster Journal."

An Analysis of Correspondence Costs and Suggestions for Their Reduction

$21,921.96 saved to a single concern in a year's time by the elimination of unnecessary words from letters is surely enough to rouse the attention of anyone having a large volume of correspondence. This remarkable achievement is reported by Mr. Louis Balsam in "System" for November, 1919; and although to an engineer, the $0.96 or even the last few dollars may appear like thousandths of an inch in a statement of concrete thickness, the general fact of a large saving seems beyond question. Mr. Balsam cities the case of one house in which costs per letter were cut from $1.12 to $0.40; and his investigation of 25 well-known concerns, whose letter costs ranged from $0.07 to $1.12 reveals many interesting facts.

Out of his experience Mr. Balsam has developed the analysis which follows:

A careful investigation and comparison of the records of many concerns seems to indicate that the following table of items is sufficiently complete to cover practically every condition:

- A. Direct Cost
  - 1. Salaries
    - a. Dictator's time cost
    - b. Stenographer's time cost
    - c. File clerk's, mail boy's and messenger's time
    - d. Mail sorter's time
  - 2. Stationery
    - a. Letterheads
    - b. Envelopes
    - c. Special printing
    - d. Carbon paper
    - e. Carbon copy paper for files
  - 3. Equipment and miscellaneous supplies
    - a. Typewriter upkeep
    - b. Ribbons for typewriter
    - c. Stenographer's supplies, including books, pencils and erasers
    - d. Phonographs and cylinders
    - e. Furniture
    - f. Special office and mailing appliances, such as scales, sealing machines and the like
  - 4. Stamps
    - a. Direct postage cost
    - b. Stamp-affixing machine costs
  - 5. Waste
    - a. Returned mail
    - b. Loss of stamps
    - c. Spoiled stationery
- B. Overhead
  - 1. Direct department expense
    - a. Salaries of correspondence officials
    - b. Incidental department expenses
  - 2. Indirect or house expenses
    - a. Salaries of general officers
    - b. Rent
    - c. Light and power
    - d. Fuel
    - e. Taxes
    - f. Insurance

This plan is intended to serve as a basis for finding the average cost for all letters sent out by a house. For practical purposes it is often more important to determine the cost of a certain kind of letter or the output of a given department.

What are apparently the most valuable suggestions brought out by Mr. Balsam's investigation are also given.

Some of the obvious but often neglected plans I need only mention, without going into the details. For instance:

1. It has been found invariably wise to impress upon correspondents the importance of covering the matter completely in every letter.

2. It is essential not to sit down to dictate a letter before all the facts are available in usable form.

3. It seems often worth while to cultivate the habit of dictating at regular periods, preferably in the morning, thus paving the way for better dictation and transcription.

4. A big element in letter costs is the stenographer who is kept waiting while the dictator answers the telephone, or talks to a caller, or looks up some necessary fact.

5. Rewriting is often traceable directly to the fact that the dictator fails to speak distinctly.

6. The time that some men spend laboriously spelling out the name of the person to whom the letter is to be written could be used to much better advantage if the dictator numbered his letters before answering them, and merely gave the secretary the number.

7. Haphazard handling of mail may represent a serious waste. A definite routine, including opening, reading, sorting, and all subsequent operations can put the letter on the same basis as if it were a piece of machinery in process of manufacture, passing speedily from one person to another so that the work is completed in the least possible time.

8. In offices where the mails are pretty heavy, a large envelop may save considerable time because the letter requires only two folds instead of three.

9. Initialing letters over the typed signature, instead of signing the full name, is another device that is more and more proving worth while.

10. Savings through detailed economies may be important: for instance, renewing typewriter ribbons, revivifying carbon paper, and dividing the pages in the stenographer's notebook so that she can take her notes and read them more quickly.

11. A grocery house found that by placing correspondence supplies within arm's reach of their stenographers, each girl could turn out more letters in a day.

12. Placing stenographers on a piecework basis may prove agreeable to them and profitable to the employer, the girl's speed and income increasing together.

No conclusive proof that one method is better than the other developed.

One excellent way to save dictating costs is to train the stenographer in the use of symbols. This method in many cases enables her to take a whole letter without the dictation of more than a word or two. For example, I have a friend, the vice-president of a Chicago packing plant, whose correspondence is quite heavy. He dictates something like this to his stenographer: "Number 8—L6, C3, Reduction Paragraph." To the uninitiated this is mere jargon. To the stenographer, however, it indicates certain paragraphs and phrases he uses in regular dictation, with which she has become thoroughly familiar.

The average letter cost to one concern is analyzed as follows (the percentages are supplied by E. & C.):

		Per cent.
Postage	$0.020	6.1
Dictating	0.208	63.7
Stenographic labor	0.074	22.6
Stationery and supplies	0.014	4.3
Folding, inserting, sealing, stamping, messenger service	0.001	0.3
Direct overhead	0.006	1.8
Indirect overhead	0.004	1.2
	$0.327	100.0

Hints on Filing

Mr. L. A. Miller, Office Manager, Willys-Overland Co., Toledo, offers some sound, if not entirely novel, suggestions on filing in "100%" magazine for December, 1919. Some of the hints we quote herewith.

There are four different systems of classifying and filing all business records:

1. Alphabetic by name—under which material is arranged in strict alphabetic order by the name of the correspondent.

2. Alphabetic by subject—in accordance with a classified list of subjects arranged alphabetically.

3. Numeric—under which the material is filed according to numbers assigned to names or subjects, necessitating the use of an index or chart for filing and reference.

4. Geographic—where papers are filed according to state, county and city because location is of greater importance than names.

The system of filing must be selected and applied to the needs of the business, as no one system will meet every need and in some cases different systems are used to advantage in different departments of the same company.

However, from our experience with subject files, we are convinced that under a subject system trouble often arises from the fact that no two persons always have the same idea of the subject to apply and frequently no single individual uses the same subject consistently.

With subject files there should be a definite classification to prevent an accumulation of miscellaneous matter. Many subject files may be converted into alphabetic files by name or location; thus work may be handled more expeditiously and with greater accuracy.

If a thorough study reveals that filing by subject is absolutely necessary, the classification of subjects should be a part of the correspondence manual, of which each dictator, stenographer, dictating machine operator and file clerk should have a copy.

Cross-filing is necessary under any system, but it should be more generous with subject files than under other systems. Too much stress cannot be laid upon the importance of having each letter cover but one subject, and very likely this one subject should be cross-filed two or three times on account of its relation to or dependence upon other subjects. In our opinion, the subject classification should contain specific instructions that certain subjects must always be cross-filed under certain other subjects.

Educating Track Foremen on Electric Railways

About 25 years ago Mr. John F. Wallace, then Chief Engineer of the Illinois Central Ry., inaugurated the "track apprentice system" on that railroad. His system consisted in taking young technical graduates, putting them in a section gang under the tutelage of a reliable foreman, promoting them to foremen in time and from then on to supervisor, roadmaster and superintendent.

At the present day many railway officials have realized the great need for replacing in some way the older section foreman who are continually dropping out of the service. It is realized that the position of track foreman is a responsible one, and that in order to make it attractive to men who are physically and mentally fitted to hold it, there must be the assurance of adequate pay and future prospects. The system under which men may be carefully trained and then induced to stay with the organization has yet to be worked out on most railroads.

The electric railways, no less than the steam railways, have felt the increasing scarcity of competent track foremen. Mr. W. L. Whitlock, Superintendent of Way, the Denver Tramway Co. has described in the Electric Railway Journal an apprentice track foreman course inaugurated by this company. The following is abstracted from his article.

Carefully selected young men are employed and systematically trained. The desirable qualifications looked for in such men include good physical condition, an education at least fair and the "sand" to stick. An apprentice track foreman who follows through his program is bound to "make good," first to his own benefit and, second, to that of the organization. In addition he has a vocation that insures his future, and a stepping stone to further advancement. These men must be supplied with sufficient incentive to make the effort worth while. Hence, in addition to the attraction of future possibilities, a scale to start with is made that should hold them to the job.

The system followed in educating the apprentice track foreman is approximately as follows:

Three months with a general maintenance repair gang. This work gives experience in ordinary track maintenance in unpaved streets and includes repairing joints, changing minor pieces of special work, repairing broken rails, culverts and spread track, cleaning dead tracks, drainage, and similar items.

Three months with a paving maintenance repair gang. This work gives experience in all phases of paving in connection with track work and includes stone block and concrete paving, grouting and protection of fresh paving, and the use of concrete mixers and pneumatic tools used in removing various types of paving.

Three months with an emergency auto truck track repair gang. This work gives experience in nearly every kind of emergency track repairs that will be encountered on any large system, teaches the value of knowing what to do and how to do it and also furnishes a means of putting "pep" into the work as it emphasizes the value of the time element on certain work.

Three months or more on construction work. This work gives experience in practical details of track construction or reconstruction, the proper methods of excavation work, ballasting, distributing material properly, joining, spiking, lining and surfacing track, back-filling and the "short cut" on track removals.

The order of work is varied with the seasons of the year so as to yield best results. At the end of a year's work, the apprentice track foreman is put in charge of a few men on minor repairs and is started on his journey.

The Denver Tramway experience has shown that three out of five men will not finish more than the first three months, but when the two who do stick it out are graduated, a valuable addition to the organization results.

The apprentice track foreman's education is gained by practical work under experienced men, supplemented by the study of standard books on track construction and maintenance which are available in the company or public library. In addition he is given practical experience and must be proficient in the proper operation of the oxy-acetylene cutting torch, the proper use of all hand tools and the operation of an electric car, an auto-truck, electric concrete mixers, gasoline concrete mixers, gasoline speeders, pneumatic tie tampers and pneumatic concrete cutters. The value of electric welding is taught, as well as methods to be followed in placing and removing temporary crossovers under traffic, and caring for switches and special work. He is also expected to familiarize himself with city ordinances affecting track construction and maintenance, the rules and regulations of water commissioners regarding the use of fire hydrants, methods of making up estimates, reporting quantities and distributing time and materials to proper accounts, and other items.

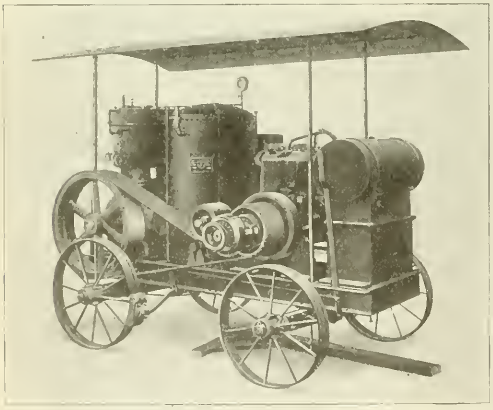
It is reasonable to expect that an apprentice track foreman will not be 100 per cent efficient at the end of a year's work, but if he has tried at all, he will have a solid groundwork of the items listed above, and time and experience will do the rest.

It costs money to train men as outlined, but experience has shown that it is a paying investment notwithstanding the fact that the "quitters" are a total loss not covered by insurance.

New Portable Compressor Outfit

A compact, portable air compressor developed expressly for the need of contractors has been brought out by the Chicago Pneumatic Tool Co., Chicago.

The air end of this unit consists of a two-cylinder single acting vertical air compressor having 8-in. diameter by 6-in. stroke water cooled cylinders and plate valves. These valves have been designed for an operating speed of 400 r.p.m., and at this speed the capacity is 140 cu. ft. per minute. The compressor discharges directly into an air receiver having a volume of 10 cu. ft. The power end of the outfit consists of a vertical 4-cylinder gasoline engine having $4\frac{3}{4}$-in. diameter by 5-in. stroke water-jacketed cylinders. This engine operates at 1,000 r.p.m. and is fitted with a friction clutch pulley of proper size to drive the compressor at its rated speed. The fuel consumption when operating at full load is 25 pints of gasoline per hour. Both engine and compressor are thoroughly cooled by a positive system of circulation. The cooling water is forced through the jackets and a high grade efficient radiator by two centrifugal circulating water pumps one driven by a belt from the compressor shaft, the other by gears from the engine shaft. A rapidly revolving fan operating directly behind the radiator draws through it a blast of cool air which extracts the heat. This system of cooling requires but little water and is simple and reliable in operation. The equipment is mounted firmly on an all-steel truck having a metal canopy top with canvas sides and ends. The front end of the truck carries a tool compartment and a 20-gal. gasoline tank, the latter mounted high enough to supply the engine with gasoline by gravity at all times. A reliable hand brake is supplied for emergencies.



Chicago Pneumatic Portable Compressor.

Again the Civil Engineer in Railroad Service

Editorial in Railway Age-Gazette.

The railroads offered the first great field for the employment of engineers. Since the very beginning of railroad construction and operation in this country, the railway engineers have stood high in their profession and not a few engineers have risen to great railway executives. Railway location and construction, in fact, all engineering work related to railway transportation, has always had a fascination for the young engineer, and for years the railways were enabled to recruit their engineering organizations from the best material of the technical schools.

This condition no longer prevails. Commencing some 10 years ago, the civil engineering graduates of the American technical schools have come to look with increasing disfavor on employment on the railroads until, as pointed out in these columns a year or two ago, the roads have had difficulty in obtaining enough first class men to maintain a high grade personnel. This diminishing interest in railway employment has gone even further so that now many of the technical schools report frankly that they are giving little attention to railway subjects for the very good reason that almost no students express any desire to follow railroad work. Replies to inquiries on this subject received from the professors of railway engineering and others in leading universities appearing elsewhere in this issue are most emphatic in this regard and there is no hesitancy in expressing opinions as to the causes.

Inadequate compensation appears to be the chief difficulty. "The graduates are offered more money by other industries" is the oft-repeated phrase in these discussions. This conclusion, however, is subject to some qualification. The tradition in this regard among the engineering students is, no doubt, based largely on conditions prior to the advent of government control. The scale of salaries now being paid by the railroads, barring certain exceptions, are approaching those prevailing in the industries, and if the railroads that raised their scale of salaries to engineers during the last two years will maintain these and if the others will bring theirs up to correspond, there should be no serious difficulty on this score.

The problem is deeper seated than the mere question of salary. An even greater source of dissatisfaction than the low pay has been the insecurity of employment. This factor has been virtually a dead issue since the summer of 1915, but previous to that time the engineering department of the railways, more than any other, was subject to an ebb and flow with each cycle of prosperity and depression. The men worked faithfully during the periods of easy money only to be laid off at the first sign of a stringency. Being forced of necessity to look for employment in lines offering a more secure tenure of service, they soon concluded that it was better to stay away from railroad work permanently.

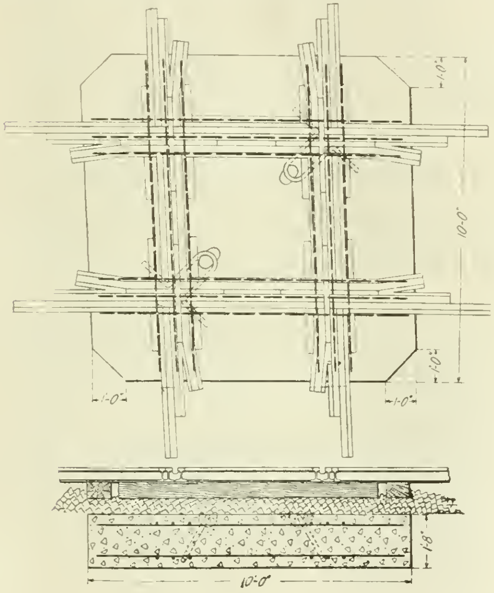
This phenomenon points to the basic fault of the employment of engineers by the railroads, which in a sense applies equally well in regard to all classes of employes. The tendency is to consider brains as well as brawn purely as a commodity to be purchased for some transitory object with little consideration of the development of the individual as a permanent part of the organization. For instance, in the conduct of a given piece of construction work, it is required to employ, say, 20 rodmen, 10 transitmen, 4 resident engineers, 4 engineer draftsmen, 2 map draftsmen, etc. They are considered largely as a temporary adjunct to this work, like so many wheeled scrapers, rock drills or steam shovels.

While these men have before them a promise of advancement to the next grade above, in case a vacancy occurs, they are too conscious of a wide gap between the individual and the real head of the department, a condition that introduces a considerable hazard in the recognition of merit. To overcome this, the railroads must follow the lead of other large industries in perfecting arrangements that will overcome these handicaps of the ponderous commercial organizations of these times. When this is done and the prospective employe, be he technical graduate or high school boy, can see a clear line of advancement that insures recognition of ability, compensation will cease to the formidable problem that it is today.

Concrete Slabs Under Crossing Frogs

For some years railroads have been experimenting in a small way with plain or reinforced concrete slabs under the track in particular spots where by reason of excessively heavy traffic with unfavorable soil conditions, there seemed to be required something more substantial than the ordinary track construction. A crossing frog even with the best ballast and soil conditions was naturally one of the first places where a foundation consisting of a concrete slab was tried out. The Railway Maintenance Engineer describes two installations of this sort on the Chicago, Burlington & Quincy Ry., and the following description is abstracted from that journal. These installations are at Hastings, Neb., and Omaha, Neb.:

The type of foundation which was used at Hastings in a slab, approximately square, with outside dimensions of 10 ft. by 10 ft. and a depth of 1 ft. 8 in., the corners being beveled or chamfered so as to form a 45° angle with the sides. The reinforcing of the blocks was accomplished by the use of ¾-in. square corrugated iron bars, which were laid 6 in. apart in sets of three and at two levels, the upper layer being 3 in. from the top and the lower the same distance from the bottom. Proper handling was assured by the use of two standard bridge slab stirrups made of ¾-in. stock and set on a 60° angle with the horizontal at opposite corners.



Plan and Section Showing Type of Construction Used at Square Crossing.

The second type used differs greatly in design from the first, following in some respects the outline of a parallelogram. It is also made in two sections per crossing or a total of six for the Omaha installation. The individual sections were exact duplicates, being poured in a two-compartment form which thus insured an identical content in each of the two parts and a continuous surface under each crossing. The total over-all length of the slab is 19 ft 2¼ in., and the width 5 ft. 6 in., with a depth of 1 ft. 8 in. Corrugated reinforcing bars of ¾-in. stock varying in length from 3 ft. 6 in. to 15 ft. 3 in. were used, and laid, as in the preceding case, in two layers at a distance of 3 in. from the top and bottom of the slab. The spacing of the bars, however, did not conform to the line of the rail, but was made in rectangular forms, the bars being two feet apart longitudinally and one foot crosswise. Two stirrups of the same specifications were installed at opposite ends of each slab, the spread part coming below the lower layer of reinforcing bars and the loop flush with the surface.

In preparing the track for the installation of these crossing foundations it was necessary to work to a prearranged schedule in order that traffic would be delayed as little as possible. The concrete slabs which had been cast at the concrete products plant of the C., B. & Q. Ry. at Havelock, Neb., and shipped on flat cars to the desired location, were brought to the crossing site in readiness for their quick handling as soon as all preparatory work had been done. All other new equipment which was to be used in necessary replacements was also brought up and kept near at hand. The actual work commenced with the digging of two pits for the slabs and the cribbing up of the tracks over the holes by means of timbers, other necessary work such as rail cutting, etc., being done before removing the old crossing and placing the new. As soon as the holes were excavated to a depth of about 2 ft. 2 in. below the base of the tie, the first crossing was removed and the concrete slab brought forward by means of a derrick car and lowered into place. The slab was then given a top dressing of about 4 to 6 in of cinders, the new crossing was lowered into place and the work of connecting it up and raising it to grade immediately started During the period of placing the first slab, similar work was being done at the other three crossings, a close check being kept to insure that not more than two were completely out of service at any one time. As a result there was a minimum delay of traffic at this point and the work proceeded rapidly, the total delay caused by trains being slightly less than an hour and that to all trains slightly less than 10 hours.

The installation of the foundation for the skew crossing at Omaha was handled in a similar manner, and in common with the crossings at Hastings, has proved to be a satisfactory solution of the requirements for large bearing surface areas under railway crossings. The cost of this work naturally varies with the conditions encountered and the amount of new material needed. In the Hastings installation the slabs averaged about $35.72 apiece and the labor, which included all work incident to changing and renewing the crossing frogs, rails, ties, etc., amounted to $212. The first cost of the concrete slab was approximately 5 per cent of the cost of the crossing, and although the labor necessary to install this type of foundation was somewhat higher than would normally be the case, the economies resulting from its use, such as decreased maintenance expenditures, and an increased length of life for the crossings more than offset this difference.

New Combination Foundation and Battery Well for Railway Signals

A new combination signal foundation and battery well was exhibited at the March exhibit of the National Railway Appliances Association. This new precast concrete product, which is being placed on the market by the Massey Concrete Products Corp., Chicago, combines in one unit a housing for batteries and other accessories with a signal foundation. The foundation inserts are of the grooved type to permit the use of widely differing signal bases without change. The maximum capacity is 66 cells of standard primary batteries.

Some of the principal advantages claimed for the signal cellar over separate foundations and housings are that it is cheaper and easier to transport because it is smaller, lighter and more conveniently handled than a battery well and a separate signal foundation, or the necessary materials required to build a foundation in the field. Its cost of installation is low because only one hole has to be dug and only one unit set. It can easily be handled from the work train with a sling chain. The signal cellar eliminates the short trunking connections between separate battery and shelter and signal, and permits the use of shorter and more direct wiring, besides presenting a neater and more compact appearance and occupying less space on the right of way.

Engineers' License Bill Passed by New York Senate.—The license bill introduced in the New York legislature by the New York Chapter of the American Association of Engineers and endorsed by the New York Section of Am. Soc. C. E. and other engineering societies in the state, was passed April 15 by the Senate. It will be introduced into the assembly immediately.

Use of Geophone for Survey Work in Mining Operations

The geophone is an instrument invented by the French during the war to detect, through the earth, the sapping and underground mining operations of the enemy. It was improved by the U. S. Engineers, and more recently has been further improved by the engineers of U. S. Bureau of Mines, and its use in connection with special sounds has been developed. Investigations of the bureau have shown the instrument to be of value for rough survey work in both coal and metal mines, for purposes of checking positions of headings, winzes or raises, being driven, sunk, or raised to make connection. It is perhaps of more value under the conditions usually prevailing in metal mines, since direction is more easily determined through rock than through coal. Information on the use of the geophone for the above purposes is given by Mr. Alan Leighton in the U. S. Bureau of Mines March Reports of Investigations, from which the matter following is abstracted:

Application of Geophone in Tunnel Work.—It is easily seen that geophones are of value when the headings of tunnels difficult to survey are coming together. Direction determinations should be made from each tunnel, and if the results are consistent the operator can be sure of his data. The results may not agree if the strata between the two tunnel heads are not homogeneous, and of course in this case little reliance can be placed upon them.

That the instruments are of practical value in this connection can be seen from the following instances: The Bureau of Mines engineers were present in a metal mine at the time when a drift and a raise had "missed." A few minutes' observation in the drift and of pounding in the raise, showed that the raise had gone up past the drift about 6 ft. in from the face and to the right. Observations made from the raise upon the sounds of the drill operating in the drift showed that the raise extended to a point 6 ft. above the drift, and that the drift was in the direction indicated by the first set of observations. A survey showed these conclusions to be correct. Again, observations were made of another raise which was being driven to the side of a drift 6 to 8 ft. from it. Observations were made of the sounds from the drill, and a point located on the side of the drift behind which the drill in the raise was apparently operating. The survey mark was then ascertained to be from 2 to 3 ft. to the right of this mark. A drill set up and operated into the survey mark did not hole through into the raise. A hole drilled at the point indicated by the geophone reached the raise, and proved the geophone to be correct within a few inches.

This instance also illustrates another application of the geophone. The surveyors had given the miners the location of the raise with regard to the drift in order to prevent accident in case a blast broke through. The geophone could have located the point easily, and frequent observations, if necessary, would have shown the progress of the work within the raise and before a blast was to be fired.

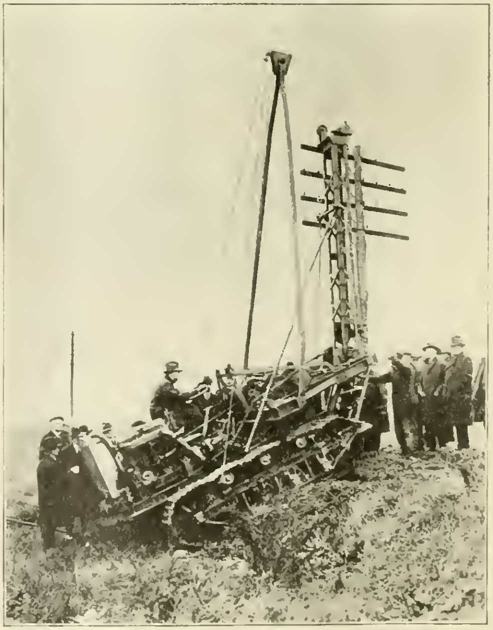
One of the advantages of the instrument is that it reproduces sound so well. Talking can be understood fairly well through 50 ft. of solid coal, and detected 150 ft. away. The sounds from mining machines are all characteristic. In fact, a Bureau engineer through 300 ft. of coal was able to name nine out of ten tools which were being operated upon the coal. In one mine where observations were being made from a tunnel heading, the mine foreman heard the workman in another tunnel preparing to blast, and ordered the Bureau engineers to retire until the blast was fired. The sounds were so clear that he did not realize at the time that the tunnel headings were then over 300 ft. apart.

Use of Geophone and Drilling Operations.—It is the custom in some localities to put down churning holes from the surface to ventilate blind stopes and to carry pipe lines. These holes often come down in the solid, and much expense is incurred in locating them and driving tunnels to them. Geophones will be of great value here, and there would be no question, of faintness of sound since churn-drilling can be detected nearly a mile away.

It is a well known fact that when the bit of a diamond drill has drilled a considerable distance below the surface, there is no simple method for determining the course it may have taken, although there are survey methods used that give approximate results. Since these bits nearly always drift away from a straight course, it is evident that any instrument making it easily possible to determine their course will be valuable. There is some possibility that the geophone may be useful for this purpose. To date, however, this possible use of the geophone has not been thoroughly studied. Observations have been made upon but two vertical drill holes. These holes, about ¼ of a mile apart, were penetrating strata consisting of alternate layers of gneiss and "black rock," pitching at an angle of approximately 45°. One hole has reached a depth of approximately 1,000 ft., the other 600 ft. At each hole it was found possible to hear the bits cutting when the geophones were placed upon the rock surface. The observations were somewhat disappointing in that the sound of the bits could be heard within but a limited area, a circle whose radius was approximately 100 ft., with its center at the drill. Since the area was so small, and presumably directly above the bit, no direction determinations could be made in the usual manner. It is believed, however, that had the bit drifted this area of audibility would have been directly above the bit and away from the drilling machinery. Observations must be made on inclined holes in order to prove this point. It is certain that should a drill-hole be put down ahead of mine workings there would be no difficulty in locating it from the workings themselves.

Self Propelled Pole Hole Boring Machine

A combination of tractor and earth boring machine, which it is claimed digs a hole and sets up a telegraph pole in about 8 minutes is illustrated below. The earth-boring machine is mounted on the frame of the Monarch tractor. When the spot at which the telegraph pole is to be erected is reached, the power from the tractor engine is switched to the earth-boring machine. This is an augur which will bore a hole in the ground any size from 2 in. to 30 in. in diameter, and as deep as 8 ft. When the hole is bored the steel tower in which the augur is contained is then used as a crane to lift the telegraph pole and set it in position.



Pole Hole Boring Machine.

Suggestions for Increasing Output of Rock Crushing Plants*

By COL. O. P. CHAMBERLAIN.

Vice-President and General Manager, Dolese & Shepard Co., Chicago.

The writer will briefly discuss the various processes of quarry operation, giving what he believes to be the most efficient methods of handling the various classes of work in the preparation of crushed rock. It will be borne in mind that much of this discussion will apply equally well to the handling of sand and gravel pits.

Removing the Overburden.—The oldest method of removing the overburden was that of plowing up the top soil and subsoil, shoveling it into wagons or carts and hauling it far enough from the theater of operations so that it would not be necessary to again move it. This was followed by the use of slip scrapers and wheelers and this again by the steam shovel and locomotive crane, small dump cars and a short line railroad with a dinky locomotive, removing the strippings from the quarry or gravel pit site to a dump. At times the expense could be materially cut by furnishing filling for some railroad embankment or manufacturing site.

A machine that is most useful for stripping where the overburden runs from 2 to 10 ft. in depth is the dragline bucket excavator, capable of turning through an entire circle. It is faster than the steam shovel and, being built with booms varying from 60 to 125 ft. in length, the larger sizes particularly do not have to move very often, and can be successfully operated with an engineer, a fireman and four pit-men.

Stripping, when practicable, should be done in the winter and early spring, before the busy operating season opens, sufficient for the season's work; then the engineer, firemen and pitmen can be transferred to a steam shovel when the operating season opens.

Drilling and Blasting—The writer knows of no more economical method of drilling for blasting than the use of the well drill. In the plant operated by him near Chicago, 5-in. holes are drilled for a 40-ft. face of Niagara limestone, at a labor cost of 10 ct. per foot of depth. Here, too, in order to keep the organization together and employ labor to the best advantage, the drilling can be done to a great extent between seasons, following the stripping. When the busy season is at its height the drillers can be dispensed with and employed in other duties in the quarry.

The writer, some ten years ago, experimented with sealing the large drill holes above the dynamite charge with a mixture of stucco (quick-setting cement containing plaster of Paris) and screenings, instead of tamping with screenings or sand only. So far as he knows, the process is original with him. Try it on a few holes and see if you cannot cut down your dynamite charge per hole 25 per cent and shape up your rock just as well as you did formerly. It won't cost much to try it and it may save you some money. Don't try to convert the "blasting boss," just stand over him and force him to make the experiment.

Many acrimonious discussions have arisen as to whether it is better practice to drill two or more lines of holes back from the face for a single large blast than to blast out a single line of drill holes for a new face. The writer realizes that he is in a minority in advocating the latter method. Theoretically, he fails to see what is gained by setting one blast against the other, which is done when more than a single line of holes are exploded at once, unless the rock is so hard as to require this treatment to break it fine enough to load. In the Niagara limestone, where most of his work has been done, the writer has tried both methods, and has convinced himself that making a blast with more than a single row of holes, which in his particular work, with a 40-ft face and 5-in. diameter holes, he drills 10 ft. apart and 10 to 12 ft. back from the face, is a waste of dynamite and a squandering of money.

Steam Shovel Loading.—Loading in small plants and, up to about 15 years ago, in all crushed rock plants, is done by hand. In England and on the Continent of Europe hand-loading is the accepted method.

In this country the greatest increase in output, the greatest economy in the employment of labor and the greatest decrease in the cost of production, can be secured by substituting loading by steam shovel for loading by manual labor, which involves somewhat extensive alterations in plant and equipment, which will be discussed later. Some idea of the saving in the substitution of the steam shovel for hand labor in loading can be gained from the following data:

A steam shovel operating at a cost of $55 per day of 10 hours and producing but 1,000 tons per day, loads at a quarry cost of 7.8 ct. per ton, against 20 ct. per ton for hand loading. These figures include a depreciation and maintenance charge on the shovel of $7,000 per year, and are conservative as, in the writer's own operation, the steam shovel performances, average over long periods, are 1,780 tons per day of 10 hours. Such operation means a loading cost of but 4.4 ct. per ton of stone loaded. Using the conservative figures of a saving of 7.8 ct. per ton in a one-shovel plant, which should produce 400,000 tons per year, the annual saving in the substitution of steam-shovel loading for hand loading is $58,800.

In the installation of a steam-shovel plant the size of the shovel should be carefully considered. In general it is well to let the initial crusher rather than the steam shovel be the limiting factor in the capacity of the plant. While you may handle present production with a 60 to 70-ton shovel, you can handle it much more comfortably with a 110-ton shovel, and you are in a position to increase your output materially without a new installation. This installation of a small, light shovel is a common mistake made in converting hand loading plants into shovel-loading plants. The error is invariably corrected after a few years of steam-shovel operation. It is well, however, to remember that while a heavy shovel means a large initial cost, this shovel, working considerably below its maximum capacity, is not apt to be delayed by vexatious breakdowns and its maintenance and depreciation is much less than that of a light shovel that is continuously crowded to its maximum.

Quarry Cars.—The substitution of steam-shovel loading for hand loading must generally include the installation of new quarry cars and motive power. Most of the hand-loading plants used men or mules or horses as the motive power for bringing the loaded cars to the foot of an incline, and the cars were handled up a steep incline to the initial crusher by a steam or electric hoist. In a shovel-loading plant a small locomotive generally replaces the man or mule motive power in the level quarry bottom.

It is difficult to load stone with a steam shovel into cars of less than 6 cu. yd. (7½ tons) capacity and a car capable of handling 12 cu. yd. (15 tons) is preferable to the smaller size. In designing your car, remember that you are building for the roughest, heaviest duty known. It takes a strongly built car to successfully withstand the impact of 4 tons of rock dropped 3 ft. to the car floor. Of course, the steam shovel engineer and craneman is not supposed to drop the rock 3 ft. or even a single foot, but sometimes they do so, with disastrous effect on light equipment.

In the writer's own experience he has practically rebuilt the 15-ton cars. They had originally axles standard for a 30-ton railroad car. Axles were broken almost daily. Now, with the standard axle for a 50-ton car they are giving good service. The original steel underframes have been replaced with heavier structural work, the pedestal castings carrying the journal boxes have been redesigned and built of cast steel instead of gray iron, the car floors which were originally 3-in. oak plank are now of 6-in. oak timbers carpeted with steel T-irons with the stems of the T's let in between the oak floor timbers.

Modification of Crushing Plant.—All that has been said in regard to the changing of a hand-loading plant to a steam-shovel loading plant assumes a modification of the crushing plant. Most of the hand-loading plants with which the writer has been acquainted contained as an initial crusher a No. 7½ gyratory crusher. Fifteen years ago a No. 9 plant was a monster in the Chicago Niagara limestone district. Today many of the No. 8 and 9 plants have been converted over into steam-shovel loading plants by interposing a No. 12 gyratory or some other type of giant crusher between the quarry and the former initial crusher and adding one or more auxiliary recrushing machines in addition to augmenting the screen capacity of the plants to take care of the increased production.

A good No. 9 plant could have been built between 1910 and 1916 at a cost of from $90,000 to $150,000. Such a plant can today be converted into a steam-shovel loading plant by the addition of a No. 12 gyratory crusher and the necessary recrushing and screening accessories, together with a heavy-duty steam shovel and new heavy quarry cars, at a cost of from $90,000 to $120,000. While the cost of such a plant transformation today is at least a 100 per cent advance on that of 1916, the practical assurance of adequate demand for one's product warrants the transformation of these small plants, even at present high prices for equipment and installation.

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*Abstract of a paper presented Feb. 12 at the annual convention of the American Road Builders' Association.

The modification of existing plants herein discussed means the changing of a 200,000-ton per year plant into a 400,000-ton per year plant. It means doubling the production with less than 50 per cent of the present staff of employes, which in itself in these days of labor scarcity is no inconsiderable item.

It means, if one cares to put it that way, the return of the entire investment for the rehabilitation of the plant and equipment within the next two years. It means a handsome return to investors and fine profits to the operators

Co-Operation Between Employes and Employers.—It has been suggested that the production of crushed rock and gravel may be increased in existing plants by working out some definite plan of co-operation between employes and the management of various plants.

It has recently been brought to the attention of the writer that one of the gravel companies in the Chicago district has operated for one season under a bonus system quite successfully. A basic cost per ton is set in accordance with past experience. Any saving below this cost is divided pro rata to the fixed wages of the employes among all of them. If there is no saving, there is no bonus and the management stands any increase above the basic cost.

There are serious objections to this system. One is that in a one steam-shovel plant whether the output is increased and the cost consequently decreased depends on the work of not more than ten men out of a total of about forty who should be employed at such a plant. No matter how diligent and faithful the other 30 men may be, the output of the plant depends on the superintendent, the steam-shovel crew and a few of the attendants at the initial crusher. It seems to the writer that a bonus to these ten employes only would be more likely to produce satisfactory results than a division among the larger number whose duties are such that their diligence or lack of diligence can in no wise affect the output of the plant.

Again, if a substantial bonus earned one month and no bonus the succeeding month, labor, in its present mental attitude, will probably demand an addition to its wages equal to the bonus.

Increasing Output by Working Double Shifts.—An effective method of increasing the output of existing plants is the working double shifts through the busy season during the months of July, August, September and October. By timing these two successive shifts so that the first starts work at or shortly before sunrise and the second follows 8½ hours after the first starts, one-half hour being allowed for luncheon for each crew, the working of two 8-hour shifts is perfectly feasible, and has been successfully accomplished.

This necessitates an increase in the normal force of not over 60 per cent as shop men and repair men may be worked 10 or 11 hours, their shift starting 3 or 4 hours after the early operating shift and continuing through the early hours of the second operating shift.

British Adopting American Excavating Methods

Steam shovels are not a new thing in England, in fact the first one was made in that country. The British steam shovel, however, is a heavy and cumbersome machine especially built for the heaviest kind of digging. English labor conditions, in the past, have not warranted extensive use of excavating equipment. Manual labor has been cheap, and often more profitable than the work of the heavy English steam "navvies." Then, too, the amount of excavating on most contracts has not been large enough to warrant the use of such heavy and expensive machinery. Recent developments, however, in the labor conditions—the shortage of manual labor and the increase of wages—have prepared the market for lighter and more easily handled steam shovels. American manufacturers have been quick to recognize the fact, and numerous shovels made in the United States are now in operation in England. The accompanying illustration shows one of these shovels—a Type B Erie—engaged in excavating a site for a factory for Adams & Beemans, Ltd., the British branch of the American Chicle Co. This is said to be the first cellar excavation ever dug by a steam shovel in any city in Great Britain. This shovel is owned by F. D. Huntington, Ltd., Engineers & Contractors, 11 Hanover Square, London. Because of the comparatively small amount of material to be handled the contractors thought at first that the use of a steam shovel was hardly warranted. The output on this job was limited by the rate at which carts could be brought into position, and was far below the shovel's capacity. Even with this hindrance the contractors state the shovel cut their excavating cost in half.

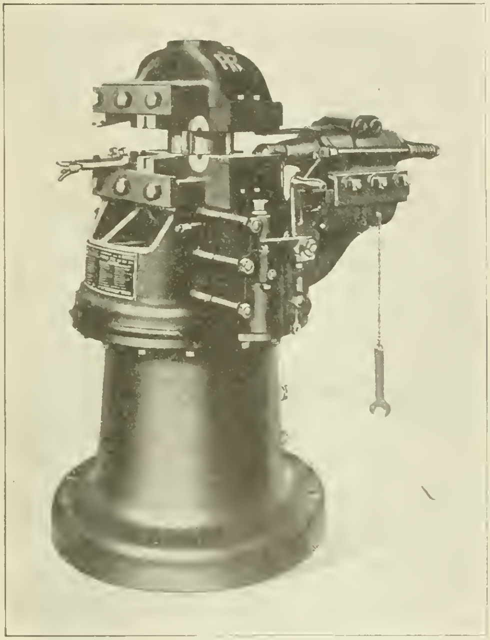
Steam Shovel Excavation for Foundation of English Factory.

Machine for Sharpening Well Drills

A machine for sharpening well drills has just been finished and shipped from the Wood Drill Works, Dale Ave., Paterson, N. J. It is claimed this machine will sharpen a drill in about 5 minutes, and make a cleaner, neater and truer job than can be obtained by blacksmithing methods customarily used for sharpening well drills. The machine is simply an adaptation on a 5-in. rock drill with certain modifications, to the new purpose. It will be used near the Bethlehem Steel Works.

New Drill Steel Sharpener

A new compressed air operated drill steel sharpener machine has been developed by the Ingersoll-Rand Co., 11 Broadway, New York. This machine, known as the I-R No. 50 Sharpener, embodies a number of new and distinctive features some of which are included in the description given below. The sharpener was designed primarily to rapidly and exactly sharpen and shank drill steel such as: cruciform steel up to 2 in. in diameter or round, hexagon, octagon, quarter-octagon, auger or spiral steel up to $1\frac{7}{8}$ in. in diameter. When fitted with special devices, it will forge boltheads, pins, stanchions, etc., in fact, nearly 200 different products have been made by it. The single lever, which controls all of the operations of the machine, is fitted with a safety locking device. The throttle valve is of the balanced spool type. The hammer cylinder is an improved valveless type of hammer drill cylinder, which permits the free moving hammer to deliver exceedingly fast and powerful blows against the end of the dolly upsetting the steel and so forming the bits and shanks with extreme rapidity. The base is substantial and rigid and needs absolutely no foundation with the exception of a few planks to level it properly and is not even bolted rigidly to them. Efficient and positive lubrication is provided for the entire machine by the Ingersoll-Rand "Heartbeat" lubricator. This is embodied in the throttle valve chest casting and works automatically whenever the machine is in action. It is provided with adjustment for regulating the quantity of oil desired.



I-R No. 50 Drill Steel Sharpener.

Causes of Fires in Railway Bridge Floors

The Committee on Service Tests of Flooring and Paving of the American Wood Preservers' Association, at the February meeting gave some instances of bridge floor fires and their origin, as quoted in the Railway Maintenance Engineer.

The roadway of the Belle Isle bridge across the Detroit river, which was destroyed by fire in 1915, was floored with 3½-in. deep creosoted wood blocks laid on a creosoted substructure. The accepted theory of the origin of the fire was that a strong wind carried sparks fro ma municipal asphalt repair wagon to the dry untreated and partially decayed sidewalk timbers, which broke into flames, igniting the creosoted substructure of the roadway. The heat developed was very intense and the collapse of the roadway timbers was accompanied by a collapse of a large portion of the steel spans.

The Missouri River bridge at Kansas City which caught fire in August, 1919, consisted of a creosoted plank roadway laid on creosoted track ties and supported by steel girders. The fire was caused by sparks from a locomotive on a railroad which crosses under the bridge, the sparks setting fire to a large nest of straw, which in turn started a heavy fire on the creosoted ties and planks. No damage was done except surface charring of the timbers, caused by the burning of the creosote.

The bridge at Portland, Ore., consisted of a double-deck structure the lower deck being used for railway traffic, while the upper deck was for street car traffic, vehicles and pedestrians. The floor system of the upper deck was composed of 4-in. Douglas fir creosoted blocks laid on creosoted planks and ties of the same material. The fire was supposed to have been caused by sparks from locomotives on the lower deck igniting dry untreated timber located in the bottom chord of the lift span, from which point the fire spread very rapidly, completely destroying the entire upper deck for a length of approximately 430 ft.

It is interesting to note that in all three cases the fire was not caused by the direct ignition of the creosoted timber itself, but by the communication of the flames from other sources, such as untreated timber or straw.

Foundation Excavation with New Excavating Machine

The accompanying illustration shows the new Smith excavator and loader, described in our March 17 issue, engaged in excavation work for the new factory of the Milwaukee Glove Works Co., at 10th and National Aves., Milwaukee, Wis. On this job two 5-ton trucks were available for hauling the material away. The average loading time for each 5-ton truck was 6 minutes and as there was a 40-minute haul it meant that there was a resultant wait of about 15 to 20 minutes between loadings. In spite of this handicap the daily 8-hour average excavation is stated to have been 150 cu. yd.

The operating crew consisted of two men—one to guide the slip and the other to operate the excavator. The excavator and loader was backed up to the curb, which was a distinct advantage in the loading because the trucks were not forced to go down into the hole—they merely drove up to the machine on the street level and received their load.

Smith Excavator and Loader on Foundation Excavations at Milwaukee.

The excavator is equipped with an 18 HP. heavy duty gas engine. The operation is controlled by a two-speed forward and a reverse lever. The slip is filled at the slow speed of 106 ft. per minute, the second speed hauls it to the excavator at the rate of 206 ft. per minute. The slip rides into the apron automatically unlocks the pivot arms which swing upward with it and dumps the load down the chute into the awaiting truck. The reverse lever is then pulled; the pivot arms swing down and lock. The slip backs out of the apron at 228 ft. per minute to the point of excavation. At this point, at right angles to the line of digging, a heavy chain is stretched between two steel stakes. Two sheaves are hooked at required points and the single heavy cable passes through them. The location of the sheaves can be quickly changed.

Personals

D. J. Brumley has been appointed chief engineer, Chicago Terminal Improvement of Illinois Central R. R., with office at Chicago.

G. H. Falmes, formerly superintendent of timber preservation for the Continental Tie & Lumber Co., has been made superintendent of the Cimarron & Northwestern Ry. of Cimarron, N. Mex

Martin J. Gillen of the Edward E. Gillen Marine Contracting Co., Milwaukee, Wis., has been appointed a member of the United States Shipping Board by President Wilson.

Frank B. Ayres, a civil engineer for the Southern Ry. in the territory around and including Louisville, has been elected general manager of the Louisville Industrial Foundation by the directors.

Maj. Wildurr Willing, United States district engineer at St. Louis and secretary of the Mississippi River Commission, has been transferred to Boston, Mass., where he will be the district engineer in charge of river, harbor and fortifications. He will be succeeded in St. Louis by Maj. Albert K. B. Lyman.

W. A. Bowden, chief engineer of the Department of Railways and Canals, has been selected by the government of Canada to act as Canadian consulting engineer in the reference to the International Joint Commission of the question of the further improvement of the St. Lawrence River between Montreal and Lake Ontario.

A. R. Raymer, chief engineer of the Pittsburgh & Lake Erie R. R., has announced the appointment of the following staff: E. W. Boots, engineer maintenance of way; F. J. Hannah, engineer construction; R. P. Forsberg, principal assistant engineer; B. A. Ludgate, assistant engineer; I. S. Raymer, signal engineer, and C. H. McConnell, electrical engineer. The offices of assistant chief engineer and assistant signal engineer were abolished.

Maj. Carl H. Reeves, an engineer of Seattle, has been appointed superintendent of the Department of Public Utilities of that city, succeeding Thomas F. Murphine, resigned. Maj. Reeves has been a resident of Seattle 27 years and has been long engaged in engineering work in connection with the street railways and construction of city utilities. He served 23 months with the United States Army during the war.

George B. Crumrine has been appointed superintendent of construction of Lock and Dam No. 4, Allegheny River, with K. H Shriver as engineer in charge. New gates have been placed in the land chamber of No. 1, Monongahela River. Two valves are reported out of commission at Lock No. 2 in the river chamber. Work on the concrete power house at Lock No. 3 now is completed to the top of the wall. Repairs are being made to the valves at Lock No. 5.

A Lincoln Fellows, senior irrigation engineer, Division of Irrigation Investigations, Office of Public Roads, U. S. Department of Agriculture, has been placed in charge of the office of the division at 301 Custom House, Denver, Colo., where he will have supervision over the work of the division throughout the Rocky Mountain region and where he will be available for consultation regarding irrigation and drainage engineering and practice. Mr. Fellows has been successively a practicing engineer in charge of the construction and operation of irrigation and drainage systems, deputy state engineer of Colorado, resident hydrographer of the U. S. Geological Survey for the Rocky Mountain region, district engineer of the U. S. Reclamation Service, in which capacity he selected and planned the Uncompahgre and Grand Valley projects, besides selecting a number of the reservoir sites now recommended for construction in connection with the proposed conservation of the waters of the Colorado River and its tributaries, State Engineer of North Dakota, and consulting and supervising engineer for other important water supply, irrigation and drainage projects. For the last two years he has been for the greater part of the time acting in an advisory capacity on important irrigation and drainage propositions in California as irrigation engineer for the division under Dr. Samuel Fortier, chief.

Industrial Notes

The Waterworks Manufacturers' Association has moved its offices from 18 E. 41st St., New York City, to Room 1003, 25 W 43rd St.

F. L. Waite, for the past 7 years advertising director of one of the oldest and largest automobile manufacturing companies in America, has resigned his old connection to undertake the direction of publicity for the New-Way Motor Co.

J. H. Thompson, an "old timer" in the automobile game, has been appointed manager of the recently established factory branch at New York City of the Four Wheel Drive Auto Co., Clintonville, Wis., makers of FWD trucks. The new branch covers a territory from Baltimore to New England.

B. C. Collier has been elected vice president of the Cement Gun Co., Inc., Allentown, Pa., in addition to his continued duties of general manager. W. J. Roberts, president of the Traylor Eng. & Mfg. Co., has also been advanced from the position of vice president of the Cement Gun Co., Inc., to that of president, and S. W. Traylor, formerly president of the Cement Gun Co., Inc., is now chairman of the board of directors.

Wallace & Tiernan Co., Inc., manufacturers of chlorine control apparatus for water and sewage purification and industrial uses, announces that Harold S. Hutton has been appointed district sales representative with headquarters in the Commonwealth Bldg., Pittsburgh, Pa. Mr. Hutton is a sanitary engineer who has previously been connected with the Public Health Service. He succeeds P. O. Collins, who is given indefinite leave of absence on account of illness.

Ray T. Middleton, vice-president and director of sales and advertising of the Kelley Metals Co., Chicago, Detroit and Los Angeles, announces additions to the sales staff of his company, as follows: C. G. Germaine, a Western representative with headquarters at Chicago; S. C. Bohannon, of Indianapolis, State of Indiana representative, headquarters at Indianapolis; M. E. Simpson, representative in the Northwest territory with headquarters at Minneapolis.

The Combustion Engineering Corporation, 11 Broadway, New York City, manufacturers of stokers, grates and other boiler room equipment relating to combustion engineering, announces with considerable regret the resignation of its vice president, in charge of sales, E. P. Moritz. Mr. Moritz had been ill for some time previous to his resignation and owing to his continued ill health it has been necessary for him to retire from active business for some time. No successor to Mr. Moritz has been named by the company up to date.

The first prize of $1,000, offered by the Lakewood Engineering Co., Cleveland, for the best treatise on industrial haulage, using Lakewood tier-lift trucks, was awarded by the committee appointed by the Society of Industrial Engineers to Clarence Irving McNair, Jr., of Cloquet, Minn., for a paper entitled "Analysis of the Application of the Tier-Lift Truck to the Pulp and Paper Industry." Second prize was awarded to Messrs. F. C. Peters, chief mechanical engineer, and G. R. Reese, assistant mechanical engineer, New Jersey Zinc Company, Palmerton, Pa. This treatise, which deals with the handling of zinc oxide in barrels and bags, contains much valuable data for the movement of bag or barrel packages. Theodore M. Prudden of the Whitin Machine Works, Whitinsville, Mass., was awarded third prize for an analysis entitled "The Tier-Lift Truck—Its Field of Usefulness."

Obituaries

Henry Foster Newell, for eight years in the engineering force of the Panama Canal Commission, died at Ancon on April 5 of influenza-pneumonia. He was born on Jan. 17, 1882, at Bradford, Pa., was engaged in surveying and general engineering work in the Western Arid States; he served in a machine gun company on the Mexican border. His principal work at Panama was that in connection with exploration and detailed mapping of the tributaries of Chagres River, and the location of works for defense of the Panama Canal. He was brother of F. H. Newell, former chief engineer and director of the U. S. Reclamation Service, and now professor of civil engineering at the University of Illinois.

Theodore N. Vail, chairman of the board of directors of the American Telephone & Telegraph Co., died April 16 at Johns Hopkins Hospital, Baltimore, Md. Mr. Vail was born in Carroll county, Ohio, July 16, 1845, of Quaker ancestry. His father, David Vail, removed from Ohio to Morristown, N. J. He was educated at the old academy at Morristown, and for a time studied medicine, but becoming interested in the telegraph, he learned to operate the key and went west in 1868 as an operator for the Union Pacific railroad at Pine Bluffs, Wyo. The next year he was appointed a clerk in the railway mail service, and here his ability to systematize and organize was soon felt. It was just after he had been promoted to the general superintendency of the railway mail service that he accepted the position of general manager of the American Bell Telephone Co. In 1885 he resigned from the original company and became the first president of the newly organized American Telephone & Telegraph Co. In 1890 Mr. Vail retired from the telephone business and purchased a large farm at Lyndonville, Vt., and interested himself in agriculture. In 1893 he made a trip to South America, and, with his customary foresight, saw the possibilities of the Argentine Republic, and made notable electrical improvements. In 1904 he returned to Vermont, but three years later he was again called upon to enter the telephone field as president of the American Telephone & Telegraph Co., of which he had been the first president.

Statement of the Ownership, Management, Circulation, Etc., Required by the Act of Congress of August 24, 1912,

Of Engineering and Contracting, published weekly at Chicago, Ill., for April 1, 1920.

State of Illinois, County of Cook, ss.

Before me, a notary in and for the State and county aforesaid, personally appeared H. P. Gillette, who, having been duly sworn according to law, deposes and says that he is the editor of Engineering and Contracting, and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management (and if a daily paper, the circulation), etc., of the aforesaid publication for the date shown in the above caption, required by the Act of August 24, 1912, embodied in section 443, Postal Laws and Regulations, printed on the reverse of this form, to wit:

1. That the names and addresses of the publisher, editor, managing editor and business manager are:

Publisher—Engineering and Contracting Pub. Co., 608 So. Dearborn St.
Editor—H. P. Gillette, 608 So. Dearborn St.
Managing Editor—H. P. Gillette, 608 So. Dearborn St.
Business Manager—Lewis S. Louer, 608 So. Dearborn St.

2. That the owners are: (Give names and addresses of individual owners, or, if a corporation, give its name and the names and addresses of stockholders owning or holding I per cent or more of the total amount of stock.)

H. P. Gillette, 608 So. Dearborn St.
Lewis S. Louer, 608 So. Dearborn St.
N. M. Rodgers, 608 S. Dearborn St.

3. That the known bondholders, mortgagees and other security holders owning or holding 1 per cent or more of total amount of bonds, mortgages or other securities are: None.

4. That the two paragraphs next above, giving the names of the owners, stockholders and security holders, if any, contain not only the list of stockholders and security holders as they appear upon the books of the company but also, in cases where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting, is given; also that the said two paragraphs contain statements embracing affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner; and this affiant has no reason to believe that any other person, association or corporation has any interest direct or indirect in the said stock, bonds or other securities than as so stated by him.

H. P. GILLETTE.

Sworn to and subscribed before me this 9th day of April, 1920.

H. DANNER,
(Seal) Notary Public.

(My commission expires Dec. 3, 1923.)

Building and Structural Monthly Issue

ENGINEERING AND CONTRACTING

Published by Engineering & Contracting Publishing Co., 608 South Dearborn St., Chicago.

HALBERT P. GILLETTE, *President and Editor* LEWIS S. LOUER *Vice-President and General Manager*
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The four rotated special monthly issues and 4 quarterly issues of E. & C. (52 in all) entirely cover the civil engineering and contracting field at $3.00 a year. Any one of the four special monthly issues may be subscribed for as a monthly at $1.00 a year. The special quarterly issues relate entirely to foreign engineering and construction practice. The *articles* in the first two issues of each month completely cover the municipal engineering and contracting field. The *articles* in the first and fourth issues of each month completely cover county engineering and highway engineering and contracting. The *articles* in the 3rd and 4th issues of each month completely cover steam and electric railway location, design and construction. See the "masthead" on the first page of the Weekly News Section for information about our weekly contract news.

Roads and Streets—1st Wednesday
(a) Roads
(b) Streets
(c) Street Cleaning
(d) Municipal Miscellanies
(e) Management and Office System

Waterworks and Hydraulics—2nd Wednesday
(a) Waterworks
(b) Sewers and Sanitation
(c) Irrigation and Drainage
(d) Power and Pumping
(e) Management and Office System

Railways and Excavation—3rd Wednesday
(a) Excavation
(b) Management and Office System
(c) Quarries and Pits
(d) Steam Railways, Construction and Maintenance
(e) Electric Railway Construction and Maintenance

Buildings and Structures—4th Wednesday
(a) Buildings
(b) Bridges
(c) Harbor Structures
(d) Miscellaneous Structures
(e) Properties of Materials
(f) Management and Office System

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Volume LIII. CHICAGO, ILL., APRIL 28, 1920. Number 17.

"I Was Educated at ——"

In reading the autobiographies in "Who's Who" we repeatedly see such statements as this: "Education: High school," or "—————— university." And in every-day talk men speak of having received their education at such and such a school or college—always in the past tense. Such facts argue all to convincingly in favor of a prevailing conception of education that is exceedingly narrow.

On the other hand the few men who really merit the title of greatness seldom speak of having been educated at a stated place during a given period of time; for they are the men who never "graduate," but are perpetual students.

If the general conception of education is false, it is largely so because so few teachers attempt seriously to teach a true conception. We concede that at "commencement day" it is the practice to tell graduates that they are about to "commence" their broader education. But single admonition rarely serves to change an established habit. And it is the habit not only to speak of undergraduate days as the educational period, but to neglect to train the undergraduate to tutor himself and to realize that he will need self-tutoring the rest of his days.

On the contrary, nearly all schools and colleges breed habits of dependence upon the teachers. Lessons are "given out" to be studied. Then, if it be pure or applied mathematics, some "examples" are set to be solved. Note that word "example." An example is an illustrative problem.

Illustrative of what? Of a rule or general principle that the teacher (or the text book) has announced. But in solving the difficult problems of life, we do not solve "examples." We ordinarily have no specific rule immediately preceding the problems, and a teacher at hand to tell us to apply the rule and to see that we apply it correctly. Instead, we either face a seeming maze of facts and principles, or we find a seeming void of suitable data. How to reason under either of these extremes is our problem. Usually we do not reason at all. We take either the simpler course of guessing, or we follow some precedent or suggestion.

This prevalent incapacity to think has always been condemned both by those who employ men and those who teach them. It is generally held to be an innate defect that can be, at best, but slightly remedied by education. We hold, however, a different opinion. If educators would abandon the idea that their function is to crowd as much as possible into the minds of students during the school years, and if, instead, they would conceive their function to be mental coaches or trainers, the first great step would be taken toward developing a nation of thinkers. We admit that this conception of teaching appears to receive general acceptance among teachers; but we insist that it is, as yet, merely a lip acceptance.

28 Pages=40 pages

The 28 pages of articles in Engineering and Contracting contain as many words as 40 pages of the size and typography commonly used by other engineering periodicals. Ours is the same size of type and type-page as that of The Literary Digest—easily read, yet giving a large volume of reading matter per page. Our 28 pages of articles would fill 112 pages of the standard 6x9 in. text-book. It would take 10 such books of 580 pages each to hold all the articles printed each year in Engineering and Contracting, to say nothing of our weekly construction news.

Take, for instance, the courses in structural engineering. Follow civil engineering students through these courses and ask yourself wherein the average student is habituated to search for information, to analyze the data, and to draw his conclusions therefrom. Is he not, rather, handed certain data already analyzed? Is he not given certain deductions for formula that he is required to memorize? Is he not told to solve certain problems by applying the formulas that he has just committed to memory? In sum, is he not habituated to look to others for every vestige of originality that exists in structural designing? And, if so, is he not deprived of the stimulus that accompanies exploration into a new field? There is as much difference between structural engineering as it is commonly taught and as it should be taught as there is between "a specially conducted Cook's tour" through the monuments of Europe, and an exploring expedition into the wilds of the Yukon Valley.

The youthful mind enjoys adventure, but what adventure is there following rules perpetually? Contrast the method that Agassiz used in teaching biology (see his biography) with the common methods of teaching anything in this country, and you will see how adventure can become a part of the process of learning.

Whenever it is suggested that the exploratory method of teaching should be generally adopted, it is usually objected that it is too slow, or too expensive, or adapted only to original minds. In the eyes of teachers who regard ability to solve ten problems in an hour as an evidence of proficiency, there never will be any merit in the acquisition of a habit. But in the eyes of the world, a habit that produces good results, year after year, outweighs a thousand fold, the ability to answer every examination question within the time limit. Burbank's habits of thought that make him the perpetual and enthusiastic explorer of nature that he is, would count for little in the final examination at our colleges, but they are worth to the world ten thousand average university degrees. Not only is this true of our greatest producers, like Burbank, but of those of more mediocre attainments. To their mental habits that render them perpetual students of their problems, perpetual seekers for more facts, they owe most of the success that makes the world their debtor.

"Debauch the Currency and Destroy the Capitalistic System"

The quotation above given is said to be, in substance, the formula that Lenine has advocated for universal application by the extreme Socialists. He has applied it with excellent results (excellent from his point of view) in Russia. Germany has applied it—perhaps unintentionally—with almost the same results. Our authority for this Lenine formula is Maynard Keynes, who was the principal representative of the British Treasury at the peace conference. In his book on the "Economic Consequences of Peace" he says:

> Lenine was certainly right. There is no subtler, no surer means of overturning the existing basis of society than to debauch the currency. The process engages all the hidden forces of economic law on the side of destruction, and does it in a manner which not one man in a million is able to diagnose. In the latter stages of the war all the belligerent governments practiced, from necessity or incompetence, what a Bolshevist might have done from design. Even now, when the war is over, most of them continue out of weakness the same malpractices.
>
> The governments of Europe, being many of them at this moment reckless in their methods as well as weak, seek to direct on to a class known as "profiteers" the popular indignation against the more obvious consequences of their vicious methods. These "profiteers" are, broadly speaking, the entrepreneur class of capitalists, that is to say, the active and constructive element in the whole capitalist society, who, in a period of rapidly rising prices, cannot help but get rich quick whether they wish it or desire it or not. If prices are continually rising, every trader who has purchased for stock or owns property and plant inevitably makes profits. By directing hatred against this class, therefore, the European governments are carrying a step further the fatal process which the subtle mind of Lenine had consciously conceived. The profiteers are a consequence and not a cause of rising prices. By combining a popular hatred of the class of entrepreneurs with the blow already given to social security by the violent and arbitrary disturbance of contract and of the established equilibrium of wealth which is the inevitable result of inflation, these governments are fast rendering impossible a continuance of the social and economic order of the nineteenth century.

The 30 leading nations of Europe had 7 billions of dollars of paper money at the end of the year 1913, but six years later this total had risen to 51 billions of dollars! Small wonder that prices of commodities have soared, and that business has been so demoralized throughout Europe. Yet there are politicians and editors who see in this demoralization only an evidence that men's nerves have been so shattered by the war that extravagance has replaced thrift. Of all the nonsense that has served and is still serving to hide the truth, none is more condemnable than is the statement that extravagance and its twin sister profiteering are the causes of general high prices.

Mr. Keynes charges the European governments either with ignorance of the true causes of high prices or with deceit in concealing what they know to be the true causes. In America, at least, we need look no farther than governmental and editorial ignorance if we would find the reason why the public is blaming high prices upon profiteering, extravagance and under production, not one of which trio of "reasons" is any reason whatsoever. The fundamental reasons for present high prices in this country are but two: (1) Increased currency, and (2) greater rapidity of money turnover. The rate of money turnover will soon begin to return to normal, but we shall have left upon our hands one and three-fourths as many dollars as we had in 1913. Thus inflated currency will continued to cause high prices for many a year to come.

Gresham's Law and Effect of Bank Deposits on Prices

To the Editor: I thank you for printing my letter in your issue of April 21, p. 449.

Replying to your criticism that Gresham's law does not apply to the case cited, I quote from the International Encyclopedia as follows:

"In latter days Gresham's law has been applied to concurrent circulation of different types of money—gold, silver and paper . . . the infusion of irredeemable paper money promotes exportation of metallic money."

In reference to the effect of decreased bank deposits on prices take some figures for illustration. Suppose bank clearings are 12 and deposits are 6 then the ratio "V" is 2; suppose clearings to decrease to 8 and deposits to 4, then the ratio is still 2, but suppose clearings decrease to 7, then the ratio is less than 2 or is 1.75, but furthermore the ratio of deposits after the decrease to deposits before the decrease is 4 to 6 or 0.67 and this will cause a decrease in prices as well as the change in other ratio "V." This is using bank deposits in place of currency, which I believe Mr. Gillette explicitly says is incorrect, but I think that is open to question at least.

That what I refer to is not imaginary is shown by the fact that this year one of the Federal reserve banks had a deficit and that it is a live question appears from the fact that last week there was a violent decline in prices on the New York Stock Exchange. JOHN WILKES.

Nashville, Tenn.

[If the issue of irredeemable paper money raises prices to such an extent in a given country as to cause a balance of trade against that country, then it will cause gold to flow out. But if all countries increase their irredeemable paper money, those that make the greatest increases will suffer losses of gold to those that make the least increases in paper money. Since 1913 our war allies of Europe have tripled their currency through the printing of paper money, whereas America has increased its currency only 75 per cent, and one-third of that increase is gold. The balance of trade is strongly in favor of America, and, in addition, Europe owes America nine billion dollars, so that no prolonged decrease in our per capita currency is probable.

We question the propriety of calling an outflow of gold due to an adverse balance of trade a manifestation of the effects of Gresham's law for Gresham's law operates even where there is no adverse balance of trade. But, as above indicated, Gresham's law (even when used in the sense given to it by the International Encyclopedia) will cause a gold influx to, rather from an efflux from this country during the next few years.

That increase in bank deposits acts precisely as an increase in currency in raising the general price level has been the belief of most political economists. But Mr. Gillette has shown that this can not be true, for bank deposits (both checking and non-checking) have increased at a far greater rate than has currency. The increase in per capita bank deposits has been so great in the past 25 years that average commodity prices would be double what they now are, were it true that an increase in bank deposits acts precisely like an increase in currency. Until this objection is met, the advocates of the old theory that checking bank deposits are "credit currency" can scarcely say that their theory is still "open to question"; for their theory is demolished unless they can meet this objection to it.

A downward trend in stock exchange prices has existed for several years, during the period of rising commodity prices. Stock values are usually based on "capitalized" prospective net earnings. If rises in commodity prices decrease the net earnings of railway and public utilities, then the prices of their stocks will recede at the very time that commodity prices are rising. And this is precisely what we have been withnessing. In addition, the interest rates have risen, thus lowering the values of stocks still more.—Editors.]

Suggested Opening Sentences for Technical Articles

By R. FLEMING.

American Bridge Co., New York City.

More than a score of books have been written during the past few years on the art of story writing. Correspondence courses are being given in short-story writing. Books and courses alike lay stress upon the importance of beginning the story aright. Three-fourths of the manuscripts submitted to the editor, says one book, are never read beyond the first page. "In the short story much depends upon the opening sentence" advises a correspondence course. Are these things not true of a technical article?

Since so much depends upon the opening sentence it may not be amiss for the writer to suggest "opening sentences" for half a dozen articles on technical subjects.

Column Formulas.

"Myself when young did eagerly frequent
Doctor and saint, and heard great argument
About it and about; but everymore
Came out by the same door where in I went."

Requisite Qualifications for a Teacher of Engineering.

In answer to a list of requisites desired in a new pastor, a church in Philadelphia received a letter saying:

"It looks to me, if you are really seeking for the man you describe, that the best thing you can do is to tie your Resolution and letter to a balloon and send them straight to heaven."

The Seven Follies of Engineering.

The seven so-called "follies of science" (real science has no follies) are: (1) The Quadrature of the Circle, (2) The Duplication of the Cube, (3) The Trisection of an Angle, (4) Perpetual Motion, (5) The Transmutation of Metals, (6) The Fixation of Mercury, (7) The Elixir of Life.

College Courses We Have Forgotten.

A Brooklyn preacher tells of being greeted on a visit to a sick parishioner with the exclamation, "I've lost my mind but I do not miss it much!"

An Argument for the Public Technical Library.

The registered number of attendants at the Engineering Societies Library, 39th St., New York City for a month in 1919 was 1,150, while for the same month at the Technology Division of the New York Public Library, 42d St., the number was 7,253.

A Help to Technical Writing.

The heading of a chapter in Fielding's "Tom Jones" is: "An essay to prove that an author will write the better for having some knowledge of the subject on which he writes."

Cost of Marble Wainscoating.—210 sq. ft. of polished Alaska marble wainscoating for a stairway in a remodeling job in a Pacific Coast city cost $700, or $3.33⅓ per square foot complete in place in April, 1920. The job involved 10 panels cut diagonally at top and bottom, with separate base and top strips. Only one bid was submitted.

Wind Stresses in Mill Building Bents

By F. E. RICHART and W. M. WILSON.

Resume of Present Practice.—The steel mill building is a type of structure which is widely used throughout the country, yet structural engineers have probably less knowledge of the actual stresses which occur in such a building, and hence of economy in design, than in almost any other sort of construction. This is true mainly because it is not known what wind pressures are exerted on buildings of various shapes and sizes and in different locations; also because the exact analysis of the stresses due to a known loading in bents of such buildings is quite difficult. Hence there is the tendency to make certain offhand assumptions, upon which to base very painstaking designs. That such buildings have stood the test of time may indicate that these assumptions were safe, if not economical.

A study of recent literature on the subject reveals a considerable diversity of opinion among engineers. For wind pressures on a vertical surface values of from 15 to 30 lb. per square foot are advocated by different textbooks and building codes, with the value of 20 lb. per square foot most widely used. Regarding pressures exerted upon a mill building the general usage is to assume a wind pressure normal to the side walls and a reduced normal pressure on one slope of the roof. In opposition to this view are the results of tests of model structures by Smith[*] and others which show that a suction is exerted upon the leeward sidewall and on the most of the roof. The effect of this is virtually to distribute the total horizontal wind pressure about equally between the two walls of the building, instead of concentrating it on the windward wall.

With an assumed loading the analysis of stresses is generally made by assuming equal horizontal reactions at the bases of the columns of the bent. When the columns are fixed at the bases, a point of inflection is assumed by many writers to be midway between the base and the kneebrace (or lowest member of the truss.) Ketchum, Kirkham, Burr and Falk,[†] and others give a formula for the position of the point of inflection in the leeward column. This equation, though based upon an approximation, probably gives nearly correct values, but in some cases is incorrectly used to locate the point of inflection in the windward column, which is actually at a lower elevation. Spofford,[*†] while making use of the conventional assumptions mentioned, prefaces his discussion with an excellent statement of the statically indeterminate nature of the problem. A very able and experienced engineer, Fleming,[††] favors reducing the intensity of wind pressure below that commonly used in designing. He also increases the allowable stress due to wind loads, and assumes the position of the point of inflection of fixed columns at one-third their height. Two other writers, Mensch and Christensen,[§§] have used the analysis of a rigid bent to study the action of mill buildings, with results which seem very reasonable.

Application of Elastic Theory.—The mill building is an elastic structure, in which the distribution of the statically indeterminate stresses depends upon the relative stiffness of the various members. While some engineers in the past have been somewhat skeptical of the so-called "elastic theory" as applied to structures, the general acceptance of such analysis, through the aid of careful tests and practical experiments, is attested by the great number of continuous girders, arches, trusses, etc., which have been built. Now just as an approximate analysis of a continuous truss may be made by treating it as a single elastic member, so the mill building bent may be roughly analyzed by considering the truss as girder rigidly connected to the columns, forming a simple rigid frame. While the elastic curve and moment of inertia of a truss are not commonly used, they are easily determined and may be used to study the behavior of the truss as a whole.

For a preliminary study the influence lines of Figs. 1 and

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[*] Smith, Alhert, Journal Western Society Engineers, Dec. 8, 1913; Eng. News, March 18, 1915.

[†] Ketchum, M. S., The Design of Steel Mill Buildings; Kirkham, J. E., Structural Engineering; Burr & Falk, Influence Lines for Bridge and Roof Computation.

[*†] Spofford, C. M., The Theory of Structures.

[††] Fleming, R., Eng. News, Feb. 4, 1915.

[§§] Mensch, L. J., Eng. News, Feb. 1, 1900; Christensen, C. L., Eng. News, March 25, 1915.

2 have been constructed by use of the slope-deflection method, and shows values of the horizontal reactions at the bases of rectangular bents, loaded on one side. While each member of these bents has a constant moment of inertia, the application of this analysis to the non-uniform members of a mill building bent gives results which are fairly accurate.

To illustrate the use of the influence lines, if a horizontal load, P, is applied at .4 of the height of the left column of Fig. 1, from the curves it is seen that the value of the left horizontal reaction, H_1, varies from .73P to .75P, and the right reaction, H_2 varies from .25P to .27P, depending upon the value of n for the frame. With a uniformly distributed load W on the entire height of the left column, H_1, varies from .70W to .71W, and H_2 from .29W to .30W.

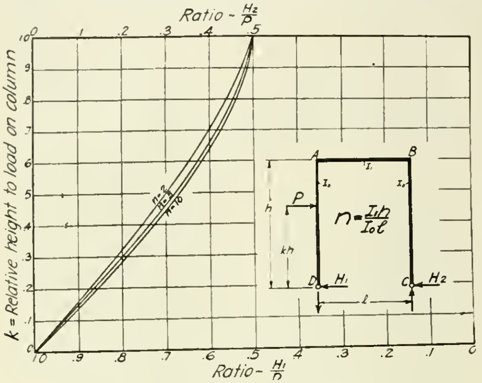


Fig. 1—Reactions Due to a Single Horizontal Load.

Similarly for the frame with columns fixed as bases, as in Fig. 2, with a uniformly distributed load W, H_1 varies from .76W to .78W, and H_2 from .22W to .24W. For the different values of n shown, the point of inflection in the loaded column is from .37h to .38h from the base; that in the unloaded column is from .55h to .51h from the base.

Conclusions from Influence Lines.—From the influence lines of Figs. 1 and 2 some important conclusions may be drawn regarding building bents in general:

1. The position of a horizontal load on the side of a symmetrical bent has a greater influence than anything else upon the distribution of the two horizontal reactions. When the load P is at D in Fig. 1 the reaction H_1 is equal to P; as the load moves up toward A, H_1 decreases to a value of P/2. Similarly the reaction H_2 increases from zero to P/2.

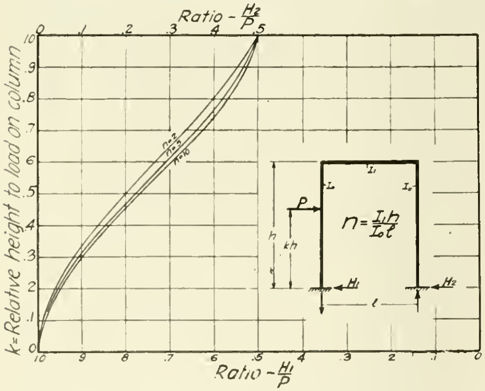


Fig. 2—Reactions Due to a Single Horizontal Load.

2. With a horizontal load on the bent a variation in the section of the member AB, indicated by a like variation in the quantity n, does not produce a very great effect upon the distribution of the two horizontal reactions. For example, a variation in n from 2 to 10 does not change the reactions appreciably. Since n as calculated from the design sheets of a number of mill building bents varied from 5 to 15, the influence line for n = 10 may generally be used for preliminary computations.

3. The horizontal reactions due to vertical loads on the top member of the bent are negligible for values of n greater than 5; hence the vertical component of the load on the roof of a mill building has little effect upon the horizontal reactions. When combined with reactions due to horizontal loads the effect is slightly to increase the leeward reaction and to reduce the windward one accordingly. The horizontal component of the roof load should be distributed equally to the two reactions.

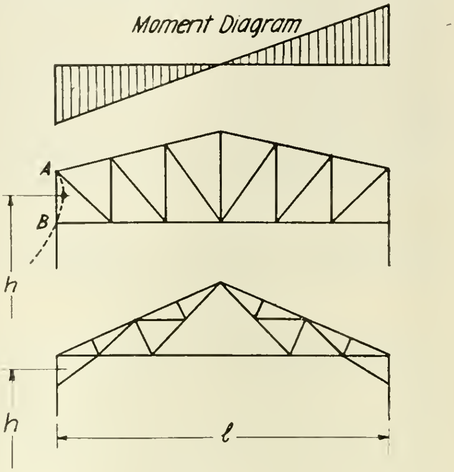


Fig. 3.

In adapting these influence lines to a mill building, certain approximations should be made. Since the moment of inertia of the truss usually varies along its length, it is convenient to substitute an "equivalent" member of constant moment of inertia. Since with horizontal loads on the bent, the moment diagram for the truss is of the general shape indicated in Fig. 3, the curvature (which varies with $\frac{M}{EI}$ along the truss) is small throughout the middle half of the span. Hence is has been found that the I for an "equivalent" member closely approaches the average I for the outer quarters of the truss, and may be so used in calculating n. From Figs. 1 and 2 it is apparent that a small error in determining I of the equivalent girder is not serious. In bents having kneebraces, the latter are considered as a part of the truss in determining I of the equivalent girder.

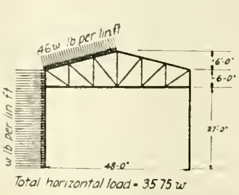


Fig. 4.

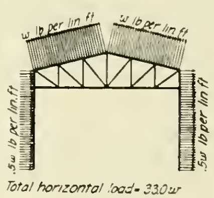


Fig. 5.

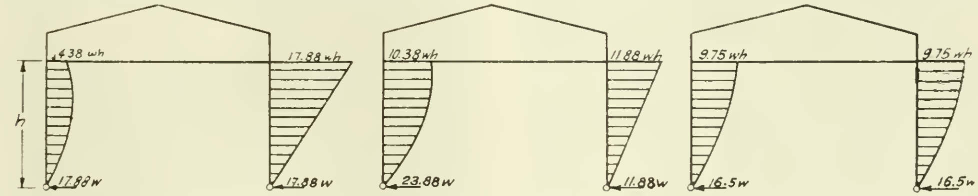
Where the depth of the truss is great compared to the height of the columns, other difficulties arise in calculating n. If, as in Fig. 3, the column and truss have hinged connections at A and B, the column is free to bend between these points. However, since at some point between A and B, the slopes of the elastic curves of the column and truss are equal, the effect of a rigid connection of the two members at that point is obtained. Theoretically the point is at .58 of the distance from A to B, or roughly, midway between A and B. Thus the value of h to be used in determining n is as shown in Fig. 3. As before noted, n may vary considerably with little effect upon the reactions.

Wind Loads and Moments.—A study of two different conditions of wind loads is presented here: (1) the conventional method of assuming full wind pressure on one side, and a normal pressure (according to Duchemin's formula) on one slope of a roof as in Fig. 4, and (2) the distribution of pressure and suction recommended by Prof. Smith, as in Fig. 5.

Further, a comparison has been made between the moments obtained by assuming horizontal reactions equal and by using the reactions found from the influence lines. Fig. 6 shows relative values of the bending moments in the columns under these various assumptions. It is seen that with columns hinged at the bases, the ordinary assumption of equal horizontal reactions produces a maximum bending moment in the column 50 per cent greater than if the reactions based upon Fig. 1 are used, and also produces higher stresses in the truss members. The loading of Fig. 5 produces equal moments in the columns and gives stresses which are generally lower than for the loading of Fig. 4. horizontal reactions, and of load on one side of building only, leads to results which are on the side of safety rather than economy. Particularly in the case of columns hinged at the bases, it would seem advisable to use horizontal reactions based upon Fig. 1. With usual values of n the windward reaction will equal .7 of the horizontal load distributed over the entire vertical side plus .5 of the horizontal roof load.

The stresses in columns due to a combined pressure and suction loading are much lower than those found in the conventional way. This loading should have considerable effect also upon the design of truss members and of purlin and girts.

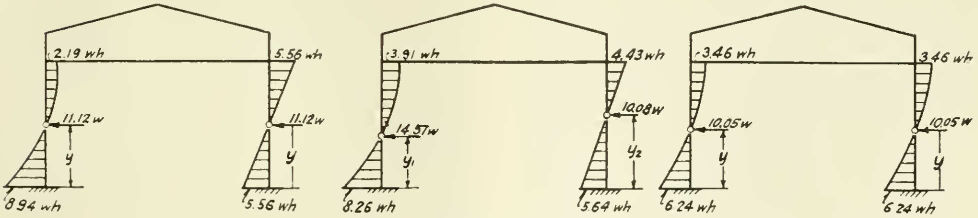
A great deal of experimental work is needed to establish a more definite knowledge of the action of wind pressure, and the same can be said regarding the stress distribution in structures of this sort. Much of the present test information lacks weight because of the small scale upon which the experiments were made. Careful and comprehensive tests on actual structures should give information of great value to the designer.



Loading of Fig 4
Assumed: $H_1 = H_2$

Loading of Fig.4.
From analysis, $H_2 = [.3 \times 30 + .5 \times 5.75]w$

Loading of Fig.5.
From analysis, $H_1 = H_2$



Looding of Fig.4
Assumed: $H_1 = H_2$ *and* $y = \frac{h}{2}$

Looding of Fig.4.
From analysis, $H_2 = [24 \times 30 + .5 \times 5.75]w$
$y_1 = .41h$ *and* $y_2 = .56h$

Loading of Fig.5.
From analysis, $H_1 = H_2$
and $y = .47h$

Fig. 6—Comparison of Moments in Columns.

The effect of the vertical suction forces on the horizontal reactions has been neglected as has been done also with downward vertical forces. It is understood that moment diagrams could have been drawn for the truss as well as for the columns; however, with the forces on the columns known the analysis of the stresses in the truss members can be made better in the ordinary way.

Referring again to the first diagram of Fig. 6, it may be emphasized that the moments produced by the assumption of equal reactions do not appear logical. Since the deformations of the windward column are as great or greater than those of the leeward one, there should be no reason why the latter should receive three or four times as much stress. Furthermore, any adjustment or permanent set which may sometimes be relied upon to relieve an overstressed part of a structure, would tend toward equalizing the moments in the columns, rather than producing the moment distribution shown.

With the columns fixed at the bases, the discrepancies between the three diagrams is not so striking, although the maximum moment under the conventional assumptions is 8 and 40 per cent greater, respectively, than that found in the following two cases.

Conclusions.—The few analyses made do not warrant any sweeping conclusions as to the correctness of any particular set of assumptions. However, the study of bents of various proportions indicates that the common assumption of equal

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Best Size of Sand for Sand Blasting.—The quality and size of the sand pebbles and the velocity and volume of the projectiles thrown against the surface have an important bearing on the results obtained from sand blasting metal preparatory to painting, according to a paper presented before the Master Car and Locomotive Painters' Association by J. W. Gibbons, Foreman Locomotive Painter of the Santa Fe Ry. Mr. Gibbons stated that any sand that is hard and firm can be used. The less dust or dirt it contains the better from every point of view. As to the velocity and volume of projectiles, he expressed the opinion that the air pressure should be not less than 70 nor more than 90 lb., gage, and the size of nozzle should not be over ⅜ in. nor less than ¼ in. in diameter. Tests of sand blasting with various sizes of sand pebbles showed that the best results were obtained by sand run through 10 by 10 and 16 by 16-mesh sieves. Mr. Gibbons stated that when it is considered that sand run through a 16 by 16-in. mesh sieve will clean practically as much surface in a day as sand run through a 6 by 6 mesh, and that the only extra cost is in the time required to sift the sand and in the per cent of sand available, and that this extra cost is more than made up in the time required to paint and surface up the metal, there can be no excuse for using a coarse grade of sand.

Pressure of Concrete on Forms—Tests of U. S. Bureau of Public Roads

Tests to determine the pressure of plastic concrete against forms have been made by the U. S. Bureau of Public Roads. While these tests seemed to accord in general with the results obtained by other investigators, they also went further in indicating the values of some of the factors influencing its results. The data from these tests were given by Mr. E. B. Smith, Second Assistant Testing Engineer, U. S. Bureau of Public Roads, in a paper presented at the recent convention of the American Concrete Institute. The paper will be published in 1920 Copyright Proceedings of the Institute. The following is an abstract of it.

The series of tests were carried out by W. E. Rosengarten in the laboratory of the research section of the Bureau of Public Roads located at the Arlington Experimental Farm, near Washington. The field tests were made during the construction of the walls and columns of a reinforced concrete building.

Test Apparatus and Methods.—The apparatus used to measure the concrete pressures were cells and gages similar to those described in the proceedings of the American Society for Testing Materials, 1917, page 641, and used for the past few years by this laboratory in measuring earth pressure behind retaining walls and under fills. The instrument consists essentially of an air-tight metal cell having a circular weighing face 10 sq. in. in area. The concrete pressures against the face of the cell are balanced by admitting compressed air to the inside of the cell. When the pressures are balanced, an electrical contact is broken, which extinguishes a light and indicates that the pressure shown on the gage connected with the air pipes is equal to the pressure of the concrete. Tests on these cells show them to be accurate considerably beyond the degree necessary for these tests, and that the movement of the face is less than one ten-thousandth of an inch to break contact, thus making the cell admirably suited for tests on pressures exerted by granular materials, soils, mud and concrete.

Several other experimenters have attempted to obtain such data, but some have been greatly handicapped by not having a suitable apparatus for determining the concrete pressures. Any scheme for determining the pressure values that depends upon a movement of the concrete at the time of making the readings is evidently not reliable. The values desired are the static pressures of concrete against an immovable surface, and not the pressures necessary to stop a moving mass of concrete; to start a movement of the mass before making the pressure readings is also undesirable.

The concrete form used during the laboratory tests was built of 2-in. planks, giving an inside horizontal cross-section of 7.8 by 9.4 in., and a height of 10 ft. Four cells were placed in the form, with the weighing face flush with the inside of the forms. Cell No. 1 was placed in the center of the base and indicated the vertical pressure. Cell No. 2 was set in the center of the rear wall of the form. Cells Nos. 3 and 4 were placed in the center of the right and left side walls of the forms, respectively. The centers of these cells for obtaining the lateral pressure were all 6 in. above the base. Air control pipes leading from all cells were arranged in order, with connections and nipples conveniently located for taking the readings on the four cells very quickly.

The materials for the concrete used in the tests were carefully weighed and mixed by hand. Immediately upon completing the mixing, the concrete was shoveled into buckets and dumped into the top of the forms. The mixing floor and the wood forms were well wetted before the test was begun. The concrete was tamped on top by the use of a long stick having a 2 by 6-in. foot on the lower end. The outside of the forms were also vibrated by striking with a heavy hammer.

The height to which the concrete stood in the column form was then measured, and the pressures on the bottom and three side cells were immediately read and recorded. The batches were varied in size, so that when a new batch was added each 10 minutes, the head of concrete in the form would increase at the rate desired. Readings were taken on the pressure cells immediately after placing the concrete, and again about 5 minutes later, or shortly before placing the next batch of concrete.

The air and the mixing water temperatures were recorded each day tests were run. Slump tests of the concrete were made to determine the consistency used in each test, and were recorded as inches slump; or where very wet, as inches diameter of the mass. Fresh batches of concrete were added every 10 minutes, until after the pressures on the cells had passed a maximum, and indicated a decided decrease in pressure. The tabulated data and results of these laboratory tests are shown in Table I.

Several field tests were run, in addition to the laboratory tests described above, during the construction of a reinforced concrete building at the Arlington Farm. The pressure cells were inserted in the wall and column forms, and pressure readings taken at the time the concrete was being poured. The concrete was machine mixed, raised in an elevator and directed into the forms through a system of chutes. It was then spaded or tamped with a stick having a small blade on the end. The concrete was a 1:2:4 mix, river gravel being used for the coarse aggregate, and the consistency rather sloppy, flowing readily around the steel reinforcing. The results from these field tests conform favorably with those obtained from the laboratory, and are shown in Table II.

What the Results Indicate.—The results shown by these experiments indicate that the fundamental pressure of concrete against the form is about 1 lb. per square inch for the first 1 ft. of head. However, this is by no means all that should be said. A study of the results reported by others, and those obtained from this series of tests show that the following factors have an influence upon the pressure: (1)

TABLE II—FIELD TESTS OF PRESSURES OF CONCRETE AGAINST FORMS.

All mixes 1:2:4, sloppy consistency.

Temperature, degs. Cent., Air.	Water.	Rate of pouring, feet per hour.	Distance (inches) cell to opp. side of form.	Maximum pressure, Lat.	Head at max. press., Lat.	Time at max. press., (mins.), Lat.
14	13	12.0	8	1.95	3.25	17
..	..	12.0	8	2.45	3.25	17
14	15	20.0	*	2.45	4.62	23
..	..	20.0	18	3.90	4.62	23
23	23	9.0	†	2.2	3.0	20
23	23	12.5	9½	1.85	2.3	11
23	23	10.6	9½	1.45	2.3	13

*3 in. to reinforcing. †18 by 28-in. hole.

TABLE I—RESULTS OF LABORATORY TESTS OF PRESSURES OF CONCRETE AGAINST FORMS.

Mix.	Consistency.	Temperature degs. Cent., Air	Water	Rate of pouring ft. per hr.	Maximum pressure, Vert.	Lat.	Head at max. press., Vert.	Lat.	Time at max. pres. (mins.); Vert.	Lat.
1:2¼:3¾		23	..	1.5	1.15	.68	**2.5**	**2.0**	90	90
1:2¼:3¾		26	..	2.7	1.45	.90	**3.7**	**2.5**	78	61
1:2¼:3¾		..	..	3.3	1.65	.73	**3.3**	**2.5**	49	44
1:3:6	Quaky*	19	21	1.63	13.5	.52	2.77	1.70	79	61
1:3:6	Quaky*	15	18	3.32	1.05	.43	4.15	2.53	70	50
1:3:6	Quaky*	19	20	6.72	1.07	.21	6.59	3.80	57	37
1:3:6	Quaky*	17	19	14.26	1.33	.41	10.00	5.12	48	29
1:3:6	Quaky*	17	21	9†	.86	.35	9.28	8.78	10	10
1:3:6	Quaky‡	21	19	1.73	.98	.90	1.71	2.08	36	66
1:3:6	Quaky‡	18	20	3.46	2.02	.85	3.72	3.22	57	57
1:3:6	Quaky‡	16	19	7.08	2.53	1.40	5.50	5.00	49	49
1:2:4	Quaky 14 in. dia	19	18	1.75	2.27	1.50	3.46	2.68	96	86
1:2:4	Quaky 13 in. dia	24	18	3.60	2.35	1.46	4.50	3.40	66	56
1:2:4	Quaky 13 in. dia	23	23	7.32	1.73	1.21	4.55	4.05	37	37
1:1½:3	Quaky	21	24	1.86	2.75	1.89	3.99	3.49	106	106
1:1½:3	Quaky 12 in. dia	20	17	3.84	3.49	2.40	4.79	4.29	66	66
1:1½:3	Quaky 13 in. dia	17	17	7.50	4.60	3.16	7.10	6.60	60	60
1:2:4	Quaky 10½ in. dia. (6½ in. Sl.)	25	18	1.78	1.75	.98	2.09	1.87	46	56
1:2:4	Dry 11½ in. dia (6½ in. Sl.)	27	18	7.35	2.41	1.93	3.33	2.83	28	28
1:1½:3	Sloppy 12½ in. dia. (3 in. Sl.)	16	15	1.84	2.37	1.17	3.05	2.55	75	75
1:1½:3	Sloppy 15 in. dia. (8½ in. Sl.)	17	15	7.66	3.31	2.05	4.80	4.30	38	38
1:2:4	Sloppy 17 in. dia. (9½ in. Sl.)	18	17	1.86	2.75	1.63	3.38	2.88	85	85
1:2:4	Sloppy 16 in. dia. (9½ in. Sl.)	19	17	7.44	1.97	1.19	3.33	2.83	27	27

*Forms dry. †In one batch. ‡Forms wet.

Rate of filling the forms; (2) cross-sectional area of the forms; (3) consistency of the concrete; (4) amount of cement in the concrete; (5) temperature of the concrete and the time of set of the cement; and (6) character of the fine and the coarse aggregate.

Sufficient data are not yet available to make final statements as to the law by which each of these factors influences the pressure of the concrete against the form. The results do show that the initial pressure under small heads is equal to the hydrostatic pressure of a liquid having the approximate density or weight of the concrete; that is, approximately 1 lb. per square inch, or 144 lb. per square foot, for the first foot head. As pouring is continued, however, this pressure soon falls below the straight line hydrostatic pressure, and the amount of this deviation depends upon one or more of the factors mentioned above.

It is important to notice that the results prove that if filling is continued indefinitely the lateral pressures near the base of the form finally reach a maximum value and then decrease gradually to zero, regardless of the fact that fresh concrete is continually added above. The vertical pressures are in all cases greater than the lateral pressures; they decrease in value after a maximum has been attained, but not to zero. The total weight of the concrete mass in ordinary construction is not supported entirely upon the bottom of the form, but because of the roughness and friction against the sides, the planking takes part of the weight or vertical pressure. Of course, for wide and shallow masses of concrete, such as floor slabs, the vertical pressure is equal to the weight of the concrete.

A summary of the data at hand seems to lead to the following conclusions regarding the effect of the various influencing factors:

Conclusions Regarding Effect of Various Factors.—The maximum pressure exerted upon the forms increases as the rate of filling increases. At a slow rate of about 1 ft. per hour the pressure is, approximately, 1 lb. per square inch, but as the rate increases beyond this value, the pressure increases approximately as the 0.3 power of the rate.

Field tests which were made in places where the distance between the form walls differed, indicate that the maximum pressures obtained increase slightly with the mass of the concrete when the consistency is wet and sloppy. This conclusion, probably, does not hold in the case of dry mixes. Reinforcing just inside the form tends to slightly decrease the pressures, but probably this effect would be neglected in determining the final pressures for use in design.

The results show in general that the maximum pressure was increased as the consistency of the concrete was made drier within the limit of workability. This is probably different from what might be expected, but the tests show it to be the case. It is probably due to the fact that under the usual conditions of placing dry concrete, it requires more tamping, which, because of its dryness, seems to develop a permanent wedging action between the particles. In the case of wet or sloppy concrete, this wedging action does not exist, as we have approximately a static fluid pressure. For low heads, the dry concrete (when tamped as usual) will give the greater lateral pressure, but for heads of 4 ft. or more and within the time when initial set becomes an influencing factor, the sloppy mixtures give the greater pressure. The average increase of pressure due to the effect of dry mixtures seems to be 0.3 lb. per square inch for each inch decrease in the standard slump test, less than a 5-in. slump.

The richness of the mix also affects the maximum pressures obtained. The richer the mix the greater the maximum pressure, the average increase being 0.12 lb. per square inch for each 1 per cent increase in the ratio of the cement to the aggregate, beyond 12 per cent.

A decrease in the temperature of the concrete retards the set of the cement, and it is natural to suppose that this is the limiting factor in the maximum pressure obtained, since the pressure increases with the head until the cement takes a sufficient set to begin to support the overlying concrete. Therefore, as the temperature is reduced and the time of the set of the cement is increased, the height of fill may be increased and thus produce or make possible a higher total pressure. Since the cement begins to set and stiffen in about 30 minutes, the maximum pressure is attained under whatever head of concrete may exist at this time. The value for H, the head of concrete, to be used in the formula given below should not be greater than one-half the rate of fill, except where agitation is vigorous and continues in a sloppy mix; then this ratio may be taken up to three-fourths.

Empirical Formula for Pressures.—An empirical formula giving the lateral pressures required for use in the design or the investigation of the strength of concrete forms, and taking into account the above numerical factors, is—

$$P = H^{0.2}R^{0.3} + 0.12C - 0.3S,$$

P being the resultant lateral pressure in pounds per square inch; H, the head of concrete fill; R, the rate of fill in feet per hour; C, the per cent by volume of cement to the combined fine and coarse aggregate; and S, the consistency in inches, or slump.

The vertical pressure is obtained by adding 0.25H to the value of P as found above, except when the inside distance between the vertical sides of the form is greater than one-half the depth of fill; then the value should be taken as equal to the weight of the concrete.

In the practical application of this formula, as with all other formulas, there is abundant opportunity for the exercise of common sense and good judgment. The formula will give pressures somewhat higher than exact values. It shows the effect of continuous and vigorous agitation of the concrete mass only as this is introduced through good judgment in selecting the value for the head of concrete, H. For usual conditions H may be taken as not greater than one-half of R. For ordinary cement in cold weather, or when continuously and well agitated, H may be three-fourths of R when the filling is continuous beyond one hour. A second pouring on top of concrete that has been in place for 45 minutes or more does not add to the pressures already existing at the bottom of the fill.

The values for C may be taken as the next higher whole number in the per cent of cement by volume, as the required accuracy does not justify fractional per cents. Values for S may also be taken only as whole numbers, since the slump test is not accurate closer than 1 in.

The value of P obtained by the formula is the lateral pressure against the form at the lowest point of the fill. Since the pressures are not uniform from top to bottom, but vary approximately as the ordinates of a parabola, the center of pressure, or point of resultant pressure, may be taken at 0.6 of the height of fill, H, from the top.

Application of Formula.—The following examples may serve to show the use of the above formula:

Example 1.—For reinforced mass concrete. Mix to be 1-3-5; consistency rather sloppy, or 9-in. slump; the rate of fill, R, to be 8t ft. per hour. The total height of concrete filled within one hour, 7 ft. Since this concrete is placed from a chute in a large form, and men are continually walking around in it, the value to be chosen for H is 6, or three-fourths of R. Then, substituting in the formula,

$$P = 6^{0.2}\,8^{0.3} + (0.12 \times 13) - (0.3 \times 9).$$
$$= 1.53 \text{ lb. per square inch.}$$

The vertical pressure = 7 lb. per square inch.

Example 2.—For reinforced concrete column. Mix to 1:2.4 consistency, 8-in. slump; rate of fill to be 24 ft. per hour. Total height of column and final fill, 11 ft., made in one pouring; since this is done in less than 30 minutes, the value for H is 11. Substituting in the formula,

$$P = 11^{0.2}\,24^{0.3} + (0.12 \times 17 - (0.3 \times 8).$$
$$= 3.83 \text{ lb. per square inch.}$$

Vertical pressure = P + 0.25 H = 6.58 lb. per square inch.

Example 3.—For thin curtain walls and reinforced bulkheads. Mortar mix, 1:5; consistency, 8-in. slump; rate of fill, 20 ft. per hour. Total height of fill in one pouring, 14 ft. The value to be selected for H should be 10, since that is the height of fill to 30 minutes, when the effect of stiffening and set begins. Substituting, we have

$$P = 10^{0.2}\,20^{0.3} + (0.12 \times 20) - (0.3 \times 8).$$
$$= 3.98 \text{ lb. per square inch.}$$

Vertical pressure = P + 25 H = 6.39 lb. per square inch.

Example 4.—For dry mix, mass concrete. Mix to be 1:3:6; consistency, 3-in. slump; rate of fill, 6 ft. per hour; distance between sides of form, 3 ft.; total height of fill within 30 minutes, 4 ft. Then

$$P = 4^{0.2}\,6^{0.3} + (0.12 \times 11) - (0.3 \times 3).$$
$$= 2.68 \text{ lb. per square inch.}$$

Vertical pressure = P + 25 H = 6.39 lb. per square inch.

Review of Molybdenum Commercial Steels

By DR. J. A. L. WADDELL,
Consulting Engineer, Kansas City, Mo., and New York City.

While certainly it is not customary for a consulting engineer to review over his own signature what is professedly a trade catalogue, this ought to be deemed an exceptional case, because the book contains information that is not procurable elsewhere. Moreover, its contents present prima facie evidence that its author wrote much more from the point of view of a practical scientist than from that of a business man advertising his product. To quote his own words, "In the presentation of a new subject of the kind covered by the preceding pages there is a natural tendency to 'put the best foot forward.' In order that any such tendency might be held in proper check, the Climax Molybdenum Co. has submitted this book—which has been over a year in course of preparation—to the officials and metallurgists of some of the largest alloy steel manufacturers and consumers in the United States. These gentlemen have extended us the great courtesy of reading and approving the foregoing pages in detail before publication. Their experience with the various molybdenum steel types described herein, completely conforms to the statements, facts, and figures set forth. These pages are therefore submitted by the Climax Molybdenum Co. without any hesitancy, as all the data conservatively represent the results of tests made on many thousands of tons commercially produced and commercially used."

During the great war there arose suddenly among the leading nations in the strife a great demand for an alloy of steel superior to any theretofore produced commercially. It was needed for the manufacture of guns, armor, munitions, automobiles, aeroplanes, etc., and this demand was met by means of the then rather rare metal, molybdenum. That element was found to have a toughening effect on both carbon steel and the various alloy steels then in use, permitting the adoption of much higher elastic limits and ultimate strengths without making the product brittle.

Its great advantage is developed through heat-treatment; nevertheless the writer has been assured that the addition of molybdenum does just as much good proportionately to untreated steel as it does to the heat-treated metal.

In the manufacture of automobiles the new alloy has specially proved its value, one of the cheapest makes thereof being now constructed mainly of molybdenum steel notwithstanding its comparatively high price, and there is no doubt that there will soon be a large demand for it in other lines of construction and manufacture in which high-grade metal is a necessity. It has been found serviceable also in the production of tool steels, especially those for tools that are to be run at great speed, for it seems that the alloy has a high resistance to injury from heating.

The present cost of the contained molybdenum in the steel alloy is $2.50 per pound; but, excepting in the case of tool steels, the amount needed is small, varying from one-third of 1 per cent to 1 per cent. Naturally, it seems desirable to keep the percentage of this expensive material down to a minimum; but where great strength and resistance to shock are desired, more should be used. It has been found advantageous sometimes to employ as much as 1 per cent.

While molybdenum can, of course, be used as the sole alloying material in steel, it is much better to employ it in conjunction with other alloying metals. It works well with chromium, which costs at present 22 ct. per pound, and with nickel which is worth today 45 ct. per pound. It has been tried with vanadium, but the value of the results effected is not commensurate with the high cost of the contained vanadium. It has been tried also with a combination of nickel and chromium, but as the amount of the latter used varies from one-half of 1 per cent to 1 per cent, and that of the former from 2 to 3½ per cent, with no great difference in the strengths obtained from the two alloying elements, it is generally more economic to employ chrome-molybdenum steel instead of the nickel-chrome-molybdenum alloy.

While a few years ago molybdenum, although widely distributed throughout the world, was found only in small quantities, and hence was classed with the rare metals, the demand for it inaugurated by the great war resulted in the discovery of at least one large deposit, viz., that at Climax, Colo. It is owned and operated by the Climax Molybdenum Co. of New York, of which Mr. B. F. Phillipson, the author of the book under review, is president.

The present capacity of the mill is 1,000 tons of ore daily; and the ore contains 1 per cent of molybdenum. In the ore reserves already developed in one deposit alone there is enough at that rate of production to ensure steady operation for more than 30 years; and the entire ore body has not yet been located. The ore is broken, ground, and concentrated by oil flotation to from 60 per cent to 70 per cent Mo S2; and the concentrates are converted into either ferromolybdenum or calcium molybdate, in either of which forms the metal is readily introduced into the steel by any of the customary methods for incorporating other alloying materials.

The writer's interest in the new alloy is primarily in connection with his specialty of bridgework; because during the last decade he has been searching constantly for a high alloy of steel, at reasonable cost, suitable in every way for the manufacture of bridges, especially those of long span. Over a year ago he learned of some of the wonderful effects on steel by the addition of molybdenum, and thinking that that metal might prove to be the alloying material for which he had been so long in search, he endeavored to obtain some data about its characteristics, costs, etc., but the information was refused him, probably being considered a trade secret. Later he obtained some of a rather general nature from the author of the work under review, together with the promise of additional detailed data as soon as they could be compiled and digested. In accordance with that promise, he received a short time ago an advance copy of "Molybdenum Commercial Steels," and immediately began a study of the possible use of the alloy in bridge building. Very quickly he encountered the fact that all of the information given referred to heat-treated metal, which in bridge-work can be used only for eyebars and pins; but he was able to obtain from the author of the work some additional data concerning the properties of a few untreated molybdenum steels. The book gives no data whatsoever about the alloy found by adding molybdenum to ordinary carbon steel; but inquiry brought to light the fact that a melt of it had been made accidentally, owing to the failure to add to the charge of molten metal the intended dose of chromium, and that the product had been tested. The increase in the elastic limit of the carbon steel by the addition of molybdenum, when both metals were heat-treated, was over 80 per cent. What the effect was on the elastic limit of the untreated steel, the writer was not able to ascertain.

With the data obtained from the source mentioned, and from other authorities as well, and also through his own previous studies on the use of various alloy steels for bridges, the writer investigated from the bridge engineer's standpoint the effect of the addition of molybdenum to the following steels.

Carbon steel.
Chromium steel.
Nickel steel.
Chrome-nickel steel.
Chrome-Vanadium steel.

He has taken the liberty of designating the alloys of these steels with molybdenum as follows:

Carmol steel.
Chromol steel.
Nicmol steel.
Nichromol steel.
Chrovanmol steel.

In Chapter V of a book which the writer is preparing on "Economics of Bridgework," there are given three diagrams from which can be seen at a glance, for all ordinary types of structure, the comparative economics in bridge building of steels having any elastic limit from that of carbon steel up to 100,000 lb. per square inch. By the aid of these diagrams, the data collected concerning all the alloys of steel hereinbefore mentioned, pound prices for bridge metals in place based on present market conditions, and certain unavoidable assumptions necessitated by the incompleteness of the available data, the writer compared the five molybdenum alloys just listed and found that, in all probability, "Chromol Steel" will be the most economic. He also tested for bridgework the question of how much molybdenum should be used in order to secure the most economic results, finding it to be not less than three-quarters of 1 per cent. If he were to be retained to investigate the question of "Molybdenum Steel for Bridges," as years ago he was called upon to investigate that of "Nickel Steel for Bridges," the first combination that he would try would be

	Per cent.
Carbon	0.25
Manganese	0.75
Chromium	0.75
Molybdenum	0.75

Of course, on account of the many assumptions of data that he was compelled to make, the writer's findings will have to be taken cum grano salis; nevertheless he is more than hopeful that in the chrome-molybdenum combination wil lbe found ere long the high alloy of steel for bridges for which he has been searching these many years. However, until the suitability of molybdenum steel for bridgework has been thoroughly tested by some bridge expert of acknowledged standing and reliability and the properties of the type of alloy finally adopted have been fully determined by numerous tests and experiments, the designers and users of bridges will not be willing to employ the new alloy in building their structures.

What Is Zoning?*

Zoning is an essential part of city planning and must be invoked to secure concentration, centralization and specialization without congestion.

Zoning must be city-wide in its treatment in order to be corelated with all of the various phases of city planning, such as rail and water terminals, the transit development, the parks and playgrounds, the thoroughfares.

Strictly speaking, zoning has to do mainly with directing and controlling the building development throughout the city. It has two phases, one dealing with the general development and organization of the city, and the other dealing with the development of the smaller district or neighborhood within the city, so as to promote the best interests of that neighborhood for residential uses or for industrial purposes or for whatever other use it is most fitted to serve.

The city usually develops a rough, natural classification such as a financial district, a produce district, a wholesale district and various residential areas, and the like. Since a building is well located and secures the best results when surrounded by buildings of similar type and use, one of the purposes of zoning, therefore, is to supplement and encourage this natural tendency toward segregation.

Consideration must first be given to business and to industry, because they are basic to the city's growth. Room for expansion in both the main business and industrial centers, as well as in the sub-business and industrial centers, must be arranged for. The development of secondary centers is important in solving the traffic problem in the main center. The segregation of residences from local business centers is mutually advantageous; likewise in the case of segregation as between residences and industries. The isolated factory which does not need terminal facilities but may depend upon motor transport should not be allowed to proceed indiscriminately amongst residences.

Even among industries, a separation as between nuisance and non-nuisance type is desirable for many reasons, but chiefly to protect the labor supply and the nearby residential areas where the laborers live.

The apartment house must not be permitted to drive out the single-family-home owner. The apartment house must be encouraged where it logically belongs. This latter feature requires elaborate study, since in Chicago the census of 1910 showed 42 per cent of the population was housed in tenements or apartment buildings, and in Manhattan over 83 per cent is similarly housed.

Not all of the above desirable results in the direction of a well-ordered city development can be obtained solely through a zoning scheme, but the general city plan should be worked out with a comprehensive zoning plan in order to obtain them.

In order to be logical and reasonable, the zoning scheme must be worked out with reference to the general conditions of the city before any attempt can be made to determine wisely what, under the general plan and in accordance with it, should be the regulations in any particular section.

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*Abstract of an address by Dr. Robert H. Whitten, of Cleveland, O., Adviser of the City Plan Commission, presented Dec. 16 at the Citizens' Zone Plan Conference, Chicago.

Modulus of Elasticity of Concrete

Little information has been available concerning the fundamental laws that govern the elastic properties of concrete. Values of modulus of elasticity are used in the design of reinforced concrete structures from a simple beam to the complicated members of a concrete ship. Knowledge of proper values of modulus of elasticity is, therefore, most important to obtain a rational design. Useful information on this subject is given in a recently issued bulletin (Bulletin No. 5) of the Structural Research Laboratory of Lewis Institute. The bulletin, abstracts from which follow, was prepared by Stanton Walker, Associate Engineer, Structural Materials Research Laboratory. It summarizes compression tests on about 3,500 6 by 12-in. concrete cylinders.

The relation between the modulus of elasticity and strength of concrete was studied for the following variables: size and grading of aggregate, kind of aggregate, quantity of cement, consistency of concrete, age at test, time of mixing, and curing conditions of concrete. The tests show that the modulus of elasticity is affected by these variables in the same manner as the strength. Tests are reported which show that the gage lengths over which the deformations are measured do not appreciably affect the determination of modulus of elasticity.

Relation Between Stress and Deformation of Concrete Under Load.—A number of equations have been offered as showing the relation between stress and deformation of concrete under load. A study of the stress-deformation data for the tests shows that this relation may be represented by the equation,

$$s = Kd^n \quad \ldots\ldots (1)$$

where s = unit stress of concrete, d = unit deformation of concrete, K = a constant depending on the strength of the concrete, and n = an exponent, approximately constant.

This equation applies for stresses below 50 to 90 per cent of the ultimate strength, or below what may be termed the "yield point" of the concrete.

There is a general belief that the ratio between the modulus of elastioity and compressive strength of concrete is approximately constant. Tests on concrete of a number of different consistencies, sizes and gradings of aggregate mixes ranging from 1:15 to about 1:3, and ages ranging from 7 days to 1 year, show that there is a general relation between modulus of elasticity and strength of concrete but that this relation is not linear. The relation may be represented by an equation of the form,

$$E = CS^m \quad \ldots\ldots (2)$$

where E = modulus of elasticity of concrete, C = a constant depending on the conditions of the test, S = compressive strength of concrete, and m = an exponent.

Four different measures of modulus of elasticity of concrete are in more or less common use, as follows:

E_i......"Initial tangent" modulus;
E_t......"Tangent" modulus at some load;
E_s......"Secant" modulus to some load;
E_d......"Chord" modulus between two loads.

The initial tangent modulus for usual concrete mixtures may be represented by the equation,

$$E_i = 33{,}000\ S^{\frac{1}{2}} \quad \ldots\ldots (3)$$

For the tangent modulus at 25 per cent of the compressive strength the equation becomes,

$$E_{t_{25}} = 66{,}000\ S^{\frac{1}{2}} \quad \ldots\ldots (4)$$

Relation Between Modulus of Elasticity and Compressive Strength.—The Joint Committee on Concrete[1] recommends "that in computations for the position of the neutral axis, and for the resisting moment of beams and for compression of concrete in columns, the modulus of elasticity be assumed as:

"(a) One-fortieth that of steel, when the strength of the concrete is taken as not more than 800 lb. per square inch.

"(b) One-fifteenth that of steel, when the strength of the concrete is taken as greater than 800 lb. per square inch and less than 2,200 lb. per square inch.

"(c) One-twelfth that of steel, when the strength of the concrete is taken as greater than 2,200 lb. per square inch and less than 2,900 lb. per square inch, and

"(d) One-tenth that of steel, when the strength of the concrete is taken as greater than 2,900 lb. per square inch.

"Although not rigorously accurate, these assumptions will give safe results. For the deflection of beams which are free to move longitudinally at the supports, in using formulas for deflection which do not take into account the tensile strength developed in the concrete a modulus of one-eighth of that of steel is recommended."

A study of this recommendation leads one to the conclusion that it is probably based on the assumption that the ratio of modulus of elasticity to the compressive strength of concrete is about 1,000.

Taylor and Thompson[2] state that while there is probably some relation between strength and modulus of elasticity, it is so complex that it will probably never be discovered. They give 1,300 as the approximate ratio of modulus of elasticity to strength.

Falk[3] concludes that the modulus of elasticity as determined by compression tests is 1,325 times the ultimate strength of the concrete.

Thacher gives the following formulas derived from Kimball's tests for concrete of different ages, which do not take into acconnt directly the compressive strength:

THACHER'S FORMULAS FOR MODULUS OF ELASTICITY.

7 days old ....$E = 2,600,000 - 700,000 \left\{\frac{\text{volume of sand}}{\text{volume of cement}} - 2\right\}$
1 month old ....$E = 2,900,000 - 300,000$ (" —1)
3 months old ......$E = 3,600,000 - 500,000$ (" —2)
6 months old ......$E = 3,600,000 - 600,000$ (" —3)

If the term $\left\{\frac{\text{volume of sand}}{\text{volume of cement}} - c\right\}$ is zero or becomes a negative quality, the entire term is to be considered zero.

All of the above relations with the exception of Thacher's assume a constant ratio between the modulus of elasticity and strength. Thacher's formulas are of limited application since they do not take into account such important variables as the grading of the aggregate and the consistency of concrete.

Schüle[4] evolves an equation for the "relation between coefficient of elasticity of concrete (in tons per sq. cm.) and its crushing strength (kilos per sq. cm.)" as follows:

$$E_b = \frac{B^2 - 25.16B + 50.38}{0.001646B^2 + 0.224B + 7.65}$$

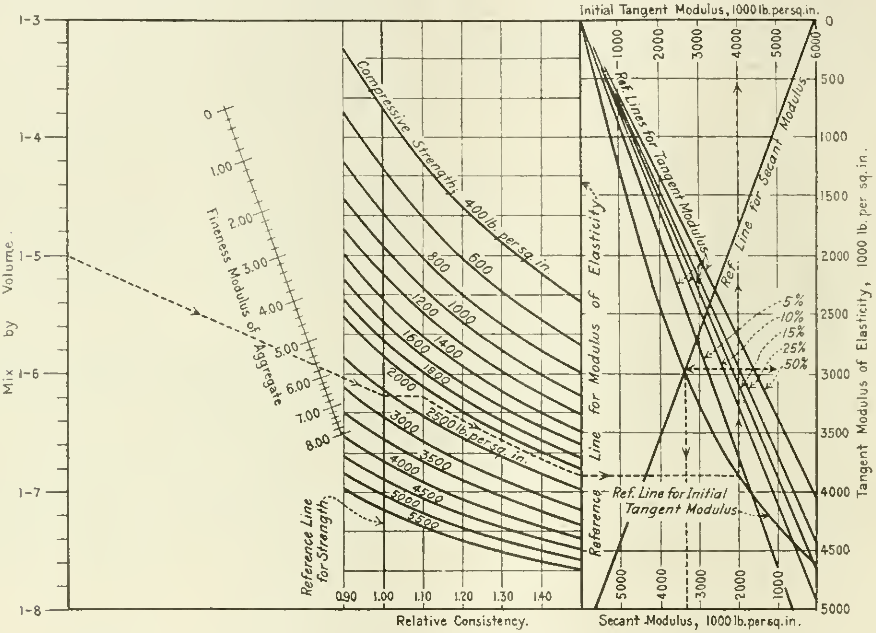
in which E_b = modulus of elasticity of concrete, tons per sq. cm. and B = ultimate compressive strength, kg. per sq. cm.

In units of pounds per square inch this equation may be written,

$$E_b = \frac{70B^2 - 25\ 100B + 717\ 000}{0.000008B^2 + 0.0157B + 765}$$

While this equation, in the author's opinion, more nearly represents the true form of the relation than any of those quoted from other writers, it is open to the objection that negative values for E_b are obtained for values of B less than 22.96 kg. per sq. cm. (330 lb. per sq. in.)

The tests show that the relation between modulus of elasticity and strength for mixes ranging from 1:15 to about 1:3 may be represented by a single curve, but the relation is not linear. Ratios ranging from about 4,000 for the low strengths to 1,000 for the high strengths are found.



Nomographic Chart Showing Inter-relation of Proportions, Strength and Modulus of Elasticity.

The relation between modulus of elasticity and strength of concrete from tests covered in this report may be represented by the equation,

$$E = CS^m \quad \dots\dots\dots\dots\dots\dots\dots\dots (5)$$

where E = modulus of elasticity of concrete, C = a constant depending on the conditions of the test, S = ultimate strength of concrete, and m = an exponent (less than 1). As given in the first part of the bulletin, for the initial tangent modulus for the usual concrete mixtures, C = 3,300 and m = ⅝; for the tangent modulus at 25 per cent of the compressive strength, C = 66,000 and m = ½. These values for E_i are based on 2,500 tests of 6x12-in. cylinders and for E_{25} on about 800 tests.

The following table shows a comparison of moduli of elasticity obtained from Equation 3 and equations given by other writers:

Compressive strength lb. per sq. in.	Modulus of Elasticity, lb. per sq. in., from — Eq. 3.	Schüle's equation.	Taylor and Thompson's ratio.	Falk's ratio.	Joint committee's ratio
1,000	2,520,000	1,430,000	1,300,000	1,325,000	1,000,000
1,500	3,170,000	2,430,000	1,950,000	1,990,000	1,500,000
2,000	3,820,000	3,360,000	2,600,000	2,650,000	2,000,000
2,500	4,440,000	3,850,000	3,250,000	3,320,000	2,500,000
3,000	4,800,000	4,400,000	3,900,000	3,980,000	3,000,000
4,000	5,900,000	5,110,000	5,200,000	5,300,000	4,000,000
5,000	6,660,000	5,640,000	6,500,000	6,630,000	5,000,000

Inter-Relation of Proportions, Strength and Modulus of Elasticity.—From the great variety of tests the interrelation of mix, grading, strength, consistency, and the various measures of modulus of elasticity has been expressed in a series

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[1] Proceedings, Am. Soc. Test. Mats., Vol. XVII, Part I, p. 202 (1917).

[2] Taylor and Thompson, "Concrete, Plain and Reinforced."

[3] Falk, "Cements, Mortars and Concretes."

[4] Proceedings, Sixth Congress, Inter. Assoc. Test Mats., New York, 1912, Second Section.

of curves and tables. A nomographic chart may be constructed for some of these variables. Such a diagram is submitted by the author. It is based on the following:

1. Amount of cement (mix).
2. Size and grading of aggregate (fineness modulus).
3. Amount of water (consistency).
4. Compressive strength at 28 days.
5. Initial tangent modulus.
6. Tangent modulus at 5 to 50 per cent of the ultimate load.
7. Secant modulus at 5 to 50 per cent of the ultimate load.

If items 1, 2 and 3 are known, items 4, 5, 6 and 7 may be obtained from the diagram.

In using this chart it should be borne in mind that it is based on one series of tests for which the concrete was mixed and cured under laboratory conditions. While it is realized that for a given mix, grading and consistency, the strengths obtained in practice will be different, it is believed that the relation of modulus of elasticity to strength will be approximately the same as given by the diagram.

Example of Use of Nomographic Chart.—Assume a mix of 1:5; 0-1 ½-in. aggregate, having a fineness modulus of 5.75; relative consistency 1.10.

1. Draw a straight line through the points representing the mix and the grading of the aggregate to the reference line for strength.

2. From this point draw a horizontal line to the line representing 1.10 relative consistency. This intersection gives the compressive strength at 28 days (2,200 lb. per square inch).

3. Follow the strength contour to the reference line for modulus of elasticity.

4. Draw a horizontal line to the reference line for initial tangent modulus. Vertically above this the initial tangent modulus (4,000,000 lb. per square inch) can be read.

5. To obtain the tangent modulus at, say, 25 per cent of the compressive strength, draw a vertical line from the point on the initial tangent curve to the reference line for tangent modulus marked 25 per cent. The tangent modulus (2,900,000 lb. per square inch) is then read on the ordinate at the right.

6. If the secant modulus at 25 per cent load is desired, draw a horizontal line from the point on the 25 per cent tangent modulus line until it intersects the reference lines for secant modulus. The secant modulus (3,300,000 lb. per square inch) is read on the bottom scale.

Incidentals Brought Out in the Experiments.—Necessarily the modulus of elasticity values of concrete are erratic because of the non-homogeneity of the material, and because of the difficulty in obtaining accurate stress-deformation data. The initial tangent moduli are particularly erratic because of the variations which may easily result in constructing the tangent. Platting the stress-deformation points on logarithmic co-ordinates reduces the error in locating the curve and avoids the necessity of constructing a tangent. A study of the stress-deformation data for a great number of materials, including woods, metals, stone, brick, brick piers, rubber, rope, and concrete of many kinds, indicates that the relation expressed by Equation 1 is applicable to all materials.

American Railway Engineering Association Becomes Member of Engineering Council.—The American Railway Engineering Association has accepted an invitation from United Engineering Society to become a member Society of Engineering Council. The association has about 1,650 members and its headquarters are at 431 S. Dearborn St., Chicago, Ill. Its president is Mr. Harry R. Safford, and its secretary Mr. E. H. Fritch. The excellent technical work done by the committee of this association in many branches of railroad construction and maintenance are well-known. The association has named as its representative upon Engineering Council its president, Mr. Safford, who is a member of the American Society of Civil Engineers and Engineering Institute of Canada. The societies now represented in Engineering Council have an aggregate membership of 45,000.

New York Legislature Passes Engineers' License Bill.—The license bill, introduced into the New York Legislature by the New York Chapter of the American Association of Engineers has been passed by both houses in the legislature and has gone to the governor for his signature.

The Engineering Mind as Exemplified by Herbert Hoover

By P. B. McDONALD,
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The Parisian newspaper, Le Figaro, says that the emergence of men like Herbert Hoover into public life marks the beginning of "an era of scientific technicians succeeding a prolonged era of jurist and political technicians." Hoover himself, as Engineering and Contracting pointed out, explains the engineering mind as one that thinks quantitatively rather than qualitatively—that thinks in costs and measurements rather than in catchwords and political shibboleths. What are the other characteristics of the modern engineering mind? How does the engineer weigh and decide questions? Since, after all, the distinguishing mark of a man or of a nation is a way of thinking—England or France, for instance, really means a national way of thinking rather than a geographical area.

Philosophers tell us that the systematic thinkers of the eighteenth and seventeenth centuries can be classified as either empiricists or rationalists. The rationalists held that genuine knowledge has its foundation in thought, in truths innate in us or a priori. These thinkers were the intellectual descendants of Plato, Aristotle, and the medieval schoolmen, of the seers who drew apart from the world and sought in contemplation the secret of all things, who held aloof and did not experiment, who applied rules deductively to the most incongruous cases. The empiricists, on the other hand, asserted that there are no inborn truths, that all knowledge comes a posteriori and inductively from sense-perception or experience and that so-called clearly perceived truths are not necessarily certain. These thinkers are the heirs of the nominalists of the late Middle Ages, those daring rebels who maintained that general concepts or universals are not real in the scholastic sense at all, but mere abstractions of the thinking mind, mere ways of expressing qualities common to many particular things. Kant and the later philosophers have sought to show the value of both rationalism and empiricism, that each brings a useful kind of knowledge, and that they are, as a mater of fact, interwoven inextricably.

But if the history of philosophy shows nothing else, it shows that, after a spell of rationalism, a community or a country needs empiricism. After an application of a priori and indisputable truths administered in the historical manner, this nation, set on the right track, requires the services of a type of mind that has experienced, that can apply engineering principles to the pressing problems of the day. President Wilson has done so much for the nation that his accomplishments are inadequately appreciated, yet his mind is of the type of the Greek philosophers and the medieval schoolmen. Though he has pointed the way, and elevated ideals to a degree, which will astonish history, he has always been a theorist, a philosopher detached from experienced, a rationalist who propounds innate and a priori ideas. Like the ancient wise-men, Mr. Wilson has always sat apart in the sun, speculating and generalizing (and his generalizations have been usually right).

Now, after eight years of rationalism, the country has an opportunity of placing at the head of its government a trained engineer, an empiricist of many experiences, a scientific organizer who has dealt successfully with men and affairs in half the countries of the world. Mr. Hoover, the most distinguished of living engineers and an excellent example of the engineering mind at its best, is an empiricist, as Mr. Wilson is a rationalist. Yet the classification is by no means a water-tight one. The two have much in common, just as empiricism and rationalism both assist in producing useful knowledge, as Kant pointed out. That Prussian philosopher explained that it is knowledge of phenomena, not knowledge of things as they are in themselves, that influence us and dictate our judgments. We can know, said Kant, only what we experience, though universal and necessary truth cannot be derived from experience. "The contents of our knowledge are derived from experience (empiricism), but the mind thinks its experiences, conceives them according to its a priori or native, that is, rational, ways (rationalism)," as Professor Frank Thilly states in his history of philosophy.

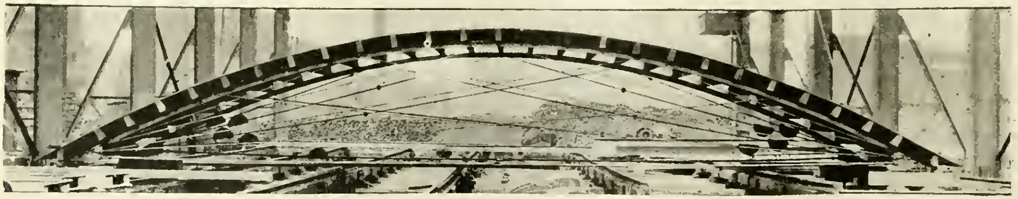
Mr. Hoover, like all good American engineers, is not lacking in innate ideas or the ability to think a priori. Though an empiricist, he is not merely that. He has an excellent American foundation, he has thought deeply and widely and inductively and deductively, and he is well read on economics, biology, and sociology. Yet his great advantage over their candidates for the Presidency lies in his vast fund of experience. He has organized individualistic technicians, apportioned responsibility among conflicting departments, cut red-tape, called bluffs, removed blatherskites, snubbed insulters, and built up constructive policies and working forces. He has traveled around the world and gone into ventures that a coward or an unimaginative plodder would have shrunk from, and he has kept steady and cool and sane. When Australians clannishly opposed the young Western American, fresh from college, he made them look foolish. When conservative Chinese looked askance at the foreigner, he showed them that they were behind the times. In London when strangers sniffed at the "Chinese engineer," he said nothing, but later these snobs ate their words. When windmills like Senator Reed, of Missouri, ridiculed the idea of a mining engineer controlling food, Hoover understood how to counteract such nonsense.

And now, has his career ended, when Hoover is only forty-six? Has the Quaker orphan from Iowa who made himself a world figure no usefulness to his country? Is the young American whom kings honored to go without honor in his own land? Has the nation no sense of fitness, nor of proportion, nor of gratitude? Is the great American ideal of government to be disregarded? Let us hope that the people are capable of recognizing ability and sincerity, and of rewarding Americanism in one of its most striking and potent personalities.

A New Steel Truss

A roof truss designed to support the load entirely and at all times by the main chord member has been used in several buildings constructed recently in Chicago. This truss was invented by Mr. H. G. Tregillus, Chicago. The principle on which the design is based is described by the inventor as follows:

If a parabolic arch is uniformly loaded it is in equilibrium and theoretically there is no need of web members to steady the arch. If the load be removed from a portion of the arch, that portion will tend to bulge upward, allowing the loaded portions to collapse. If, however, the unloaded portion is restrained against bulging by being anchored to the arch ends or the abutments then the loaded portions cannot fall; it is evident that to flatten at one point an arch must bulge at another point. The force with which the arch pulls against this anchorage is equal to the weight that would be necessary at that point to make the load uniform along the arch, and the stress in the web rods is computed from this upward force.



Two Tregillus Trusses Assembled for Testing.

The two trusses were designed to support 25 lb. per square foot live load and 10 lb. per square foot dead load, when placed 14 ft. c. to c. on a span of 49 ft., 3 in., c. to c. of bearings. They supported a test load of 39 tons uniformly distributed in addition to weight of structure. One-half the load was then removed, leaving 19½ tons supported on one side of the roof.

The advantages claimed for the truss include: Simplicity of manufacture in the shop, and ease of erection on the job. In the shop, for trusses to meet ordinary requirements, the only operations involved after the material has been cut to length, are marking, punching, bending, threading and partial assembling. In erection, while there is no objection to riveting the trusses when in place, because of their peculiar construction they give just as satisfactory results when they are only bolted. This eliminates the necessity of having skilled workmen and special equipment at hand. As a matter of fact a truss can be assembled and placed with no other tools than a monkey wrench, a drift-pin or two and a set of falls.

Methods of Making Surveys on Bridge Construction

Useful suggestions on the functions and work of the resident engineer on bridge construction are given by Dr. J. A. L. Waddell, in a recent Journal of the Western Society of Engineers. The instructions regarding surveys are particularly interesting, and accordingly are reprinted below:

The resident engineer will receive from the main office a general-layout drawing in which the main controlling points and the distances between them are clearly indicated on a profile and a plan. It remains for the resident engineer to set a series of hubs or other monuments that will locate on the ground at least the more important lines of distances shown on the plat. These reference points should be set with a view to their accessibility during the entire period of construction—a point frequently overlooked by the inexperienced resident engineer.

Where one or both banks are of an elevation as high as the deck of the new structure, so that an observer can see over the tops of all piers, a large part of the instrument work can frequently be done directly from the center line of the bridge, which is the best condition; but where the shores are low, as soon as piers are built they obstruct the view, hence recourse must be had to offset-lines and triangles for both position and alignment of the piers. In any event there should be laid out in advance at least two independent methods of checking the position and the alignment of all piers, because one method may be blocked at any time by the necessary movements and uses of the contractor's plant, or by storage of materials, etc.

Where the crossing is long enough to require triangulation, consideration should always be given to the prevailing direction of the wind and its effect on the smoke from the engines and boilers in use around the work. The direction from which the best unobstructed view of the crossing can be obtained should be selected for the observations necessary to the checking of position during the construction. While it is very desirable that the base line should end at or pass through the main points of triangulation, it is not really essential; and frequently time can be saved and accuracy of measurements increased by locating the base line where it may be washed out by the first high water. Where the conditions for the length of time necessary to make the triangulation are excellent for accurate work (for instance, along the Missouri River at ordinary water), there are frequently long, high-and-dry sand bars, which are firm, and on which long base lines can be quickly and accurately located; and then the distances between points on shore can be determined with great precision, and the web of triangulation stations may be extended indefinitely.

Methods Used in Survey for Missouri River Crossing.—The sketch shown in Fig. 1 is from an actual survey for a crossing of the Missouri River, Point A being in thick willows and cottonwood timber, and Point B on a high bank where buildings, timbers, etc., were in the way of direct base-line measurements. There was a small slough of water near the bank at A, but a high sand bar made the accurate measurement of the base DCE a simple matter. DE was 750 ft. long, and DC 350 ft.; and the points D, C, E were set in the same line, C being at the intersection of the lines AB and DE. The base was measured four times with a 50-ft. tape, supported at 25-ft. intervals, and pulled to a uniform tension; and a glass thermometer tied along the tape was read at each measurement. East of the points A, B, C, D, and E was marked by a small indentation made with a center punch in the head of a copper nail driven in the top of a large hub. The three angles at each of the points A, B, D, and E, and the four at C were then measured by repetitions both to the right and to the left, and the sum of all the angles (both interior and exterior) at each of the four exterior points gave for each point an angle which varied from 360 degrees by a small quantity—never in excess of 10 seconds. This amount was then logically divided among all the angles at the point; and after the various angles had been thus corrected, the angles in each triangle were adjusted to make their sum 180 degrees. The triangles ADE, DEB, ACE, BCE, ACD, and BCD were solved, and then the several separate determinations of the length AB were compared. The distance was found to be about 1,400 ft.; and the greatest difference in the lengths of the three separate determinations was 11/64 in. This work was done with a high-grade engineers' transit having a 6¼-in. plate divided to minutes; and the observations were made on a slightly cloudy day. Targets were used on A and B, a pencil point serving as a flag on points D, C, and E. The entire field work was completed in two days by three men; and it will serve to give an idea as to what may be considered good work in respect to speed and accuracy combined. Had the weather not been favorable for observations, the time and the number of observations required would have had to be increased in order to obtain such good results. The probable variation from the true length in the mean length of the three determinations is about 1/8 in. Points A and B were carefully referenced back onto the banks, and the distance between them was used as a base for extending a triangulation system for a survey up and down the river.

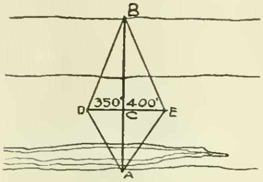


Fig. 1.

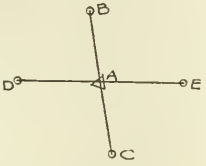


Fig. 2.

Precautions for Accurate Centering of Instrument.—The determination of distances and angles with great accuracy in bridge surveys requires that close attention should be given to the important matters of setting the instrument exactly over the point occupied, and having the line of collimation directed exactly through the points to which the angles are to be measured; i. e., errors of eccentricity and phase are to be avoided.

A slight but uniform air current may deflect the plumb-bob so that, even though the observer has used care in his set-up, he may be ⅛ in. or more eccentric to the true point; and this error may be increased several times in the distances sought, and thus cause material errors in angles. By use of the following precautions the instrument may always be centered over the point with great accuracy.

In Fig. 2 let the triangulation point be A, and let B and C be two hubs with sharp, well-defined points on their tops in the same vertical plane as A. Let D and E be two more similar points in a second vertical plane through the point A, making a good intersection with the plan through BC, i. e., as near 90 degrees as convenient. The distances of the points from A should not be too great—generally from 25 to 50 ft. Set up on A by use of plumb-bob, then with instrument carefully leveled sight on B, clamp, plunge the telescope, and sight on C. If the transit is in adjustment and exactly over the point A, the cross hair should bisect C; but if it does not do so, the instrument should be shifted a small amount on the adjustable head and the test tried again. When adjusted in one plane, unclamp and turn to point D, clamp, plunge, and try point E in the same manner as was done at C. In shifting the head a small amount, it will be found advantageous to take a soft lead pencil and mark the inside of the hole in the shifting head on the sliding plate underneath before loosening the head to move it. This gives a definite mark to gage the movement. After a few trials one can make this test for position in a very few minutes; and, if close work is required, the time involved is well spent. One second of arc for a radius of one mile amounts to about ⅜ in.; and for a radius of 1,000 ft. it is .006 ft.

In ordinary survey work the round or octagonal poles in common use are excellent tools and serve their purpose well, but when it is desired to determine angles in a triangulation system to the nearest 5 seconds of arc, when the lengths of the sides of the triangles are approximately 1,000 ft., the use of such a pole, when perfectly centered over the point and truly vertical and steady, may cause an error of 7 seconds in the angle read, on account of phase. On long shots the vertical wire may cover the entire image of the flag pole, which would render accurate pointing difficult. These troubles are easily avoided by the use of fixed targets, which present a plane surface to the telescope, thus avoiding phase, and which have a white space in the center to be sighted to of such a width that the cross hair will appear as a black line with a clear white line on each side. For targets to be viewed at a distance of 1,000 ft., the white field in center should be about ⅜ in. wide.

Use of the Tape.—For measurements of length the steel tape should be employed, the use of rods or bars on bridge baselines being long out of date; and unless the expensive and complicated ice-bar apparatus, as developed by the U. S. Coast Survey, is adopted, the modern steel tape, when properaly manipulated, will give more accurate results than rods or bars. There is a new steel tape (called the Invar) now available, in which the coefficient of expansion is very small, being 1/25 that of an ordinary steel tape. The use of one of these would be quite an advantage in measuring base lines, as the hardest thing to ascertain in such work is the actual mean temperature of the tape at the time of the measurement. With the use of the Invar tape, the difference becomes so small that an error of several degrees in the mean temperature would not be appreciable in the length of an ordinary bridge. As yet these tapes are very expensive, hence, not in common use.

The tape should be supported at intervals of about 20 or 25 ft., there being no material advantage gained by the adoption of closer supports. These supports should be spaced at equal intervals, as nearly as may be, so as to facilitate the computations in correcting for sag and for inclination of the tape. For effect of sag and the computation of length betwen end supports see Johnson's "Surveying." Before measuring a base line one should determine the true length of the tape by comparison with other well-determined standards. This should be done by the contractor for the superstructure, he furnishing for the field work a tape which has already been compared with the one that will be used in measurements for fabrication in the shops. The U. S. Government will make comparisons and furnish a certificate of the true length of any steel tape for a nominal fee.

The determination of the horizontal projection of a distance measured with an inclination of not to exceed 18 ft. in 100 ft. is best made by the formula $L_1 = L - \frac{h^2}{2L}$, where $L =$ the distance measured between supports, $L_1 =$ the true horizontal projection of L, and $h =$ the difference in elevation of the two ends of L. Where L is repeated several times with uniform length, the corrected value for

$$\Sigma L \text{ becomes } \Sigma L_1 = \Sigma L - \Sigma \frac{h^2}{2L}.$$

This calculation can ordinarily be made by slide rule with sufficient accuracy.

Extremely long tapes are a nuisance; and a 100-ft. one is long enough for all ordinary base-line work. A very narrow tape is best for accuracy, as the effect of the wind on a tape increases rapidly with its width. There is no necessity for tapes to be fully graduated.

As the determination of the length of base depends on the correctness of several different tape-lengths, it becomes extremely important that, each time the tape is used, its end graduation be transferred to the top of reference hub with accuracy, the measuring to head of a tack or nail not being sufficiently exact. The marking of ends should be made on soft-metal plates nailed to tops of hubs; and the marking should be done with a sharp steel scribe. The exact line of base should be scribed on the plates before making the precise tape measurements. Base lines should be measured at least four times—an equal number of times in each direction; and the front and the rear chainmen should change places each time the base is measured. The final lengths as determined from each one of four measurements should not vary from the arithmetical mean of all the measurements by a distance exceeding 1/200,000 of the total length.

Having completed the main base-line, a second one should be measured, preferably on the opposite side of the river and on the other side of the bridge, and so situated that its ends can be easily connected with the main triangulation and its length computed from the first measured base, thus giving a check on the accuracy of the entire work. This test should always be applied, but the second base need not be long. If there be good reason therefor, it can be located on the same side of bridge or river as the first base line. In any event there should be a line of known length to close on and check the accuracy of the entire work.

After the base lines have been established and monumented, the engineer should proceed to make an accurate survey in order to determine the distances between well-located monuments set back on the bank out of the way of all operations of construction. Next he should calculate the position of each pier or foundation in reference to these monuments, then make a scale drawing showing the bridge, the shore lines, and the centers of piers; and on this indicate the best location for additional monuments that will give good intersections for finding the pier centers. There should always be three lines for intersection in order to locate any pier point. Monuments should be set for all of these lines, so that in locating a pier the transits may be used as direction instruments only, i. e., merely to project a line from or between two well-established points. In accurate work, using high-grade engineers' transits graduated to 1 minute only, three lines thus intersecting over a pier should form a small triangle, the greatest length of any side of which for a bridge-crossing 1,000 ft. long should not exceed ⅜ in.; and the center of the triangle of intersection should be taken as the point.

Angles are to be measured by the method of repeating; and all angles meeting at a point, including the large exterior angle, should be measured and their sum taken from 360°. This check will show a small error, which should be distributed properly among the angles at that point. After all the angles have been measured and adjusted to their probable values around the point, a second adjustment should be made so that the sum of the interior angles of each triangle of the system will equal 180°. If the measurements and adjustment at the points have been carefully done, this last correction will be very small. Calculations are then to be made to determine the lengths of all lines joining the various points of the system.

Monuments.—The setting of the monuments which are to be used for reference throughout the work is a very important operation, and should demand the close attention of the engineer to ensure that they are correctly placed, are of ample size and durability to outlast the field work, and are so built or located that they will not be likely to settle or move during the time they are needed. But as the only way to be sure that a monument has not moved is to check its position, relative to other monuments, each monument should be well referenced by at least three other points so placed that even a very small movement in one of them can be easily detected. Where the work does not justify the setting of concrete monuments, very good results can be obtained by the following method: Use a 4-in. post auger to drill into the ground at least 3 ft. at the point where it is desired to set a hub. This can be quickly done in ordinary soils. Then drive a 4-in. x 4-in. piece of timber into the hole with its top flush with the surface of the ground, then with a spade dig out a cone-shaped hole around the top of hub to about 1 ft. deep and refill this hole with cinders or gravel. A hub set as above will not be disturbed by the freezing of the ground; and, if protected from being struck by wheels or heavy objects, it will retain its position indefinitely. Moreover, it makes a fairly good temporary bench mark. For recording the exact point on the top, a good method is to nail a small plate of copper or zinc on the head of the stake or hub, and then mark the exact point with sharp lines scratched in the plate with a steel scribe, or by a small hole made with a center punch. A copper nail driven in the hub, and the exact point struck thereon with the punch also makes an excellent mark. Strong posts should be set around important instrument-stations to prevent disturbance and the piling of materials on hub. In setting triangulation stations, the elevations of the tops of hubs should be carefully determined when running the levels, in order to provide bench marks to be used for the control of building operations. These should be recorded where they may be quickly referred to, then each one of these hubs becomes a T. B. M. (Temporary Bench Mark) and may be used for the levels of construction. They should be checked from time to time for possible settlement.

Leveling.—In determining the elevation of bench marks, several completly-closed circuits should be run over the benches, one-half to the right or clock-wise and the others in the opposite direction; and the mean elevations thus determined should be used as the true elevations. In case the work extends over a comparatively large area, in determining the most probable height of bench marks, the adjustment of the observed heights may be made by the method of least squares; but where the work has been carefully done, this refinement will be found to give results differing very little from those wherein the arithmetical mean of several well-made measurements is used for the true value.

One of the most difficult things that an engineer is ever called upon to do with a level is to make a crossing of a wide river with an accurate line of levels; nevertheless, it can be done. The main source of error in such work is the great difference in the refractions of the line of sight over the land and over the water. This is especially true near the middle of the day when the sun is shining, hence no river should be leveled over under such conditions. When the river is 1,000 ft. or more across, two levels and two rods should be used simultaneously, one rod and one instrument on each side of the river, the rods being held on the same points for both instruments. One should work carefully but rapidly; then, just as quickly as it can be done, the two survey parties should cross the river and repeat the observations. This method tends to correct all but the personal errors of the observers and is a check on them. In case several sets as above are to be made, it would be well to have the survey parties exchange the instruments for half the observations.

In setting shoes and machinery tracks of swing spans, etc., the greatest care should be taken to obtain the closest results of which the level and rod are capable; but in measuring excavations and ground surfaces, the nearest tenth of a foot is sufficient, and in setting forms for concrete work in the majority of cases 1/100 ft. is close enough. In such lines as hand-rails, curbs, etc., a change of 1/100 ft., if it occurs in a comparatively short distance, may be detected by the eye, and hence more careful work is required therein. The general public will notice and detect a small error in either grade or alignment in a hand-rail or curb and will criticize the work adversely, while comparatively large errors in other parts of the structure will never be noticed by them.

Long Span Concrete Construction.—An 80-ft. clear span concrete roof construction of the arch type with tie rod was used at the Riverdale, Ill., plant of the Acme Steel Goods Co., according to "Concrete in Architecture and Engineering." In this type the reactions of the roof arches which really form the three chords of an arch are vertical as for simple beams and no bending is produced by them in the columns, the horizontal thrust being taken by the tie rod. Since the rafters are straight, their proportioning is a simple matter, the bending moments being due practically to vertical loads. The moments due to axial thrust is small, and indeed the axial thrust reduces the bending stresses produced in the lower side of the rafters by their own weight and that of the roof, so that the compressive stress in the upper side of the rafters governs the design. A smaller amount of reinforcing may therefore be used than is required for a simple beam. The entire roof framing is very simple. Economical spacing of the columns can be worked out practically without regard to the roof framing, since the rafters are framed to a girder connecting the column tops.

Present Inefficiency of Lumber Mill Labor.—In one of the northern lumber states where the standard of efficiency is believed to be higher than in the southern sections, only one mill out of 12, in a recent detailed report, stated that the amount of work accomplished per hour was about the same as before the war. One said that what was done in 30 hours in 1914 now took 35 hours. One plant estimated that labor was 13 per cent less efficient than before the war, another noted a 27.4 per cent decrease in efficiency, another 20 per cent, another 27 per cent and another stated that their efficiency had decreased 30 per cent.

SCIENCE OF MANAGEMENT

Application in Civil Engineering and Construction Fields

The term Science of Management was coined by the editor of Engineering and Contracting and first used in "Cost Analysis Engineering" (1908) and explained more fully in "Cost Keeping and Management Engineering" (1909). The last named book, which contains ten laws of management and many subsidiary principles, was the first book on the science of management. In the columns of this journal many additional laws, principles and detail methods of management have been published. This section, which appears weekly, may be regarded as a serial sequel to the two books above named.

Shall City Planning Be Controlled by Expediency or by Idealism?

City planning seems about to emerge victorious from its trial by Indifference, Skepticism and Ridicule. Its investigators, whether professional or non-professional, have, with few exceptions, recognized and acclaimed its merits. Popular approval has swung toward it, as is indicated by the constantly increasing number of cities that are establishing commissions and committees for its conduct.

Nevertheless modern city planning is still far from being a complete development as either art or science. Because of this immature condition there are wide variations of opinion as to its proper functions and the means by which its ends are to be attained.

The "City Beautiful" movement, after accomplishing a little here and there, apparently is gasping its last under the weight of indifference and ridicule, its essentially worthy objective lost because it was undertaken without due regard for the economic and psychological factors involved. "City Planning," on the other hand, by virtue of an intelligent reckoning of the forces which it must overcome, has already made some notable achievements, and is rapidly rising in public favor. It shortcomings and failures generally have been such as are inherent in youth.

The foregoing is at variance with the thought expressed by Mr. Frederick L. Ackerman in a paper entitled "Where Goes the City-Planning Movement?" published in the Journal of the American Institute of Architects; but the prestige of Mr. Ackerman's name in this field precludes any light dismissal of his opinion. We quote a large part of Mr. Ackerman's paper:

Shall We Study Symptoms or Causes?—"It would appear that any attempt to translate the so-called 'fundamental principles' of city planning into such terms as would constitute a program of action which might serve to give direction to the growth and expansion of our material environment along rational lines should be largely, if not entirely, confined to the realm of scientific investigation and not that of mere speculation, for, as suggested, results are obtained through definite action applied to real situations. Scientific investigation should, therefore, address itself first to an inquiry into the causes which have brought about the conditions which, in turn, give rise to that activity which finds its justification on the ground that by action along certain lines changes in our ill-arranged material environment may be effected which will make for the common good. Hence it would appear that we have a point of departure which may serve as a basis of an inquiry into the present status of the city-planning movement and an evaluation of the work of those engaged in it. This same inquiry may well be used as the basis for a program of action to be applied to real situations.

Normal Tendencies.—"Without attempting to state in precise terms what may be said to express the underlying purposes of city planning as conceived by its spokesmen; without attempting to set forth the activities which its professional advocates assume should fall within the field of their own special concern; without venturing an opinion as to what constitutes the relative importance of the various professional or lay points of view which must be recognized, given a hearing, and made use of, it is clear beyond any question that the opinion which most readily passes current among the spokesmen of the movement is that city planning is an activity which takes its point of departure in the conditions of the present, and which proposes to accomplish its purpose largely through restrictive legislative action by following a course strictly limited to considerations of 'expediency.' This regard for 'expediency' which is clearly to be observed in every phase of the activity, is set up by the spokesmen of the city-planning movement as constituting a meritorious attribute which should appeal to the conservative and to those who are inclined to the perpetuation of the status quo ante.

"For in the past it has been the conservatives and those particularly interested in holding the ground already secured who have largely controlled the affairs of government and the economic situation in general and, naturally, any program of action which fails to be accorded a high rating among such as hold to the conservative point of view would not stand any very good chance of immediately becoming effective, and hence the advocacy of what is rated as 'expedient' is set up as a 'fundamental principle.' To be more specific, one of the 'fundamental principles' set forth for guidance in connection with the preparation of zoning ordinances, and the like, is that any scheme which is to be advocated should give due regard—in fact, it should above all recognize those 'normal tendencies' of city growth.

The Movement Now Stultified.—"This, perhaps, is as good an illustration as need be given in support of the contention that the entire movement, as now staged, is so based upon consideration of 'expediency' as to amount to inhibition or stultification.

Political Expediency vs. Real Progress.—Zoning, like all other measures of a restricted character, is supposed to be directed toward the curbing of definite, well-established or 'normal tendencies' which have resulted from the freedom of action that is guaranteed in certain fundamental political documents and supported by judicial decisions. By restrictive action, such as is exercised in the zoning of cities, for example, an exterior authority, so far as the individual is concerned, is created to step in and limit action. Since that group of problems with which we are confronted in our maladjusted urban centers arises out of the so-called freedom of action of individuals, it would appear reasonable to assume that what we need to check is no less than those 'normal tendencies' which arise out of the comparative freedom of action of individuals. But this does not appear to be the conclusion of the spokesmen of the movement, for while it is generally stated that the problem is to be solved by restrictive legislative action, it is at the same time stated as a 'fundamental principle' that by restrictive action we should not thwart 'normal tendencies.' Of course, this may be using an illustration in which other considerations may very properly be taken into account by way of qualifications; but for the question at hand, it should be sufficiently accurate.

"It is this attitude of projecting a future upon the basis of the status quo ante which effectively thwarts progress and prevents the acquisition of any accurate knowledge concerning what are the causes which work for present maladjusted conditions. It is a pure assumption that out of present tendencies better conditions in the future may be created; what evidence there is at hand points clearly in the opposite direction.

"The inclusion of considerations of 'expediency' among the 'fundamental principles' which should direct the work of those professionally engaged in the work of city planning, or which are to be used in the work of stimulating public opinion, lifts the entire activity right out of the field of scientific research and investigation, and lodges it in the field of politics. This statement is not made with a view of depreciating the value of considering a program of action in terms of practical politics; it is rather presented with a view of pointing out that any scientific study of causes cannot properly be rated as such so long as it takes possible political consequences into account in the formulation of its conclusions. This is precisely the error into which the spokesmen of the movement have fallen in their attempt to organize the so-called fundamental principles' of city planning. The so-called 'fundamental principles' are merely suggestions of what is deemed to be politically expedient at the present juncture. At the present juncture what is deemed politically expedient is action, which coincides with "normal tendencies"; and 'normal tendencies' are obviously the cause of our trouble. Translated into workaday English, 'normal tendencies' represent the right of the individual to use the community as a machine for procuring individual profits and benefits, without regard to what happens to the community. That is why we have maladjusted communities. That is why we shall continue to have them, so long as the spokesmen of city planning continue to proclaim that adjustment can be had without touching the sacred causes of the maladjustment.

Unwarranted Asumptions.—"'Normal tendencies' is merely descriptive of developing situations which now prevail and are clearly evident upon superficial examination. Action in any field takes a direction determined always by the resultant of the forces acting upon that field. That the more powerful of the forces which gives rise to a situation are beneficent does not follow; and hence any assumption that 'normal tendencies' or tendencies which may be said to be characteristic of a developing community will result, if followed, in a better condition is not warranted.

"Hence it is that a study of the forces out of which the present maladjustments have arisen, should be the focus toward which inquiry should be directed, and an inquiry of this nature would concern itself with causes and not with prospective political situations. An inquiry of this nature would reveal the prospect, likewise, of what would likely be the outcome of any attempt to deal with these causes by other methods than that of allowing them to operate in comparative freedom—which is what is meant by saying that in our schemes of restrictive legislation we should above all recognize and allow 'normal tendencies.'"

We wonder whether or not it is Mr. Ackerman's belief that following the establishment of a set of ideal ends there should be no departure therefrom nor any compromise on any achievement short of full accomplishment. His language leaves the impression that such is his thought. In fact, there is recurrent throughout his paper the suggestion that the present is entirely evil, and that salvation is to be found only in complete revolution.

Is Revolution Necessary.—Upon such an attitude, the reader must pass judgment for himself. But although the present writing cannot be elaborated into a reply to a hypothetical argument in support of this view, it is appropriate to remark that though revolutions have been necessary in many phases of human affairs, and undoubtedly will be necessary again, they have never, so far as we can remember, resulted in the complete and permanent elimination of all that constituted the old order. Sometimes they have been most patently misdirected. With these and other facts in mind, it is well for one tempted to seek relief in quick revolution to ask himself whether the elimination of evil reasonably to be expected (not ideally to be desired) will be enough to compensate for the destruction of good, the concomitant hardship on the undeserving, and the cost of rebuilding in the place of both the good and the evil which would be destroyed.

In the field of city planning in particular, the newness of the movement and the rapid progress now being made argue eloquently against a violent overturn. In fact, are we not presumptuous in attempting to provide perfectly for the future when the present is as defective as it is? If the most careful thinkers of a generation ago could have stricken from the earth what they chose of man's works and institutions, and substituted therefor the best devices of their own imagining, would they have provided for present traffic requirements (to cite a single example only)? And who, today, is so wise that he should destroy the apparently good in order to provide for the conditions and needs of 50 years hence? Were the plotters of Manhattan Island utter fools when they provided for a traffic predominantly across the island instead of up and down it? With all their mistakes, we believe that in this respect, at least, they used such foresight as the time permitted; and it ill behooves the present day New Yorker to say that they should have known better. A whole city destroyed to make way for their ideal would not have saved today's condition.

Let these comments convey no misapprehension that we slight the value of planning ahead. Our contention is merely that the sacrifice of present benefits to future expectations may easily be to no purpose.

Tendencies, Normal and Abnormal.—Issue must also be taken with Mr. Ackerman's attack on "normal tendencies" as a controlling factor in city planning. He explicitly asserts that "normal tendencies" may not be beneficial or desirable; but beyond this, his repeated statement that normal tendencies are the cause of our trouble, and his failure to recognize exceptions, conveys the impression that he considers all present tendencies to be both normal and bad. While it is perhaps probable that his extreme emphasis on this point produces an impression he did not intend, the attack on any following of 'normal tendencies" is so sweeping, and forms so large a part of his argument that it deserves a reply.

The tendencies most commonly recognized, studied and treated are those of character of development or occupation of particular districts. A certain section of a city, then, develops as a residential district as the result of a presumably normal tendency. Both the tendency and its development are essentially good. A small manufacturing establishment comes to the district—not because of the normal tendency which draws residences, but for some exceptional reason such as the ownership of a piece of land or the desire of the proprietor to bring his work near his home. This is out of keeping with all else in the district, and should be classed as an "abnormal development." The almost certain following of other industries to the detriment and perhaps the ultimate destruction of the residential use are the result of a tendency which we believe may very properly be called "abnormal." What does city planning do in this case? It checks, and has in scores of cities checked, the abnormal tendency and development, thereby encouraging the normal: nor has action of this character been confined to residential zones. We grant that there are developments of specific character in locations not suited to them in topography nor by man-made environment, and some such it may be desirable to change; but in considering the change let us not be more eager to alter the works of man than those of nature.

The Time Element.—An immediate benefit, or one in the very near future, is of greater value than is the same benefit at a distant date. This should be self-evident, and the point of view which allows this generation's debt to posterity to obscure the sight of what it owes itself (or keeping the subject on a strictly altruistic plane—of what you and I owe each other) is indeed difficult of comprehension. That there is a debt to posterity we do not deny; nor are we devoid of pride in the works which this generation shall leave to those to come; but we do hold that our present reasonable welfare is paramount. Do those who look too largely to the future perhaps forget that postponement means loss in value? A dollar today is a dollar, despite high cost of living; but a dollar to be received 50 years hence is today worth only 23 ct. if interest at the rate of 3 per cent, or only 5½ ct. if interest is 6 per cent.

Expediency.—While to some extent sanctioning the use of expedient means, Mr. Ackerman is sweeping in his denunciation of considerations of expediency in determining the ends of city-planning. Quite properly his attack is directed chiefly toward political expediency; but with less violence it seems lodged against the entire field.

As regards economic expediency it appears to us that cognizance must be taken as carefully in city planning as in any other field of human endeavor. In fact, because of the breadth of the field and the far-reaching effect of whatever is done within it, it appears that more than ordinary consideration should be given to the economics involved.

Undoubtedly the well-being of the citizens present and to come is the all-embracing end of city-planning. Within this broad scope, however, two major questions immediately arise:

1. To what extent shall the present be required to provide for the future?

2. To what extent shall the individual be made to suffer for the good of the community?

Our answer to the first of these is practically contained in what has preceded. Briefly, it is that provision for the future is proper up to the point where it imposes no more than a reasonable burden upon the present. That the definition of a "reasonable burden" will involve further discussion we, of course, admit, but this article can not deal at length with that point. It is sufficient that it indicates the existence of a practical limit.

The second question can be answered as briefly: To the greatest extent possible the individual should be relieved of suffering, and the burden should be distributed, equitably throughout the community. "Equitable distribution" in this case, like "reasonable burden" in the former, opens a field for discussion not to be undertaken here. Also there are usually legal factors determining the possible extent of individual relief. Obviously an early step should be the remedy of these factors wherever they are unjust.

Furthermore, the citizenship is entitled to the maximum sum total of good obtainable from its labor; and the composition of that maximum is a thing not easily to be determined. Certainly it can not safely be left to the workers in any one field, for their view of their own needs dims all others. Perhaps, faulty as it is, our own loose system of allowing public opinion to decide such broad matters is better than any other; and if this is so, hope of improvement must lie in education in the necessary fields. But in all of this is not economic expediency clearly manifest? We think it is.

The exercise of political expediency has been so frequently fraught with evil that one may well hesitate before offering any form of approval of it. Yet, frankly, we do not believe that it should be always rejected. As an illustration, take the case of a certain western city which has two large and expensive concrete bridges in its north end residential district—the aristocratic end in popular estimation, although it houses thousands of working people. Another bridge is needed in the north end, but the south-enders, jealous of their rights, will defeat any bond issue for this structure, unless the issue is made to provide also for one or more south end bridges which are admittedly less needed than are certain other improvements in the city. As the matter stands, there are just two courses open—the politically expedient one of yielding to the south-end demand, and the indefinite postponement of needed improvements. But, it may be argued, "this is not the pernicious form of political expediency against which our shafts are directed: it is when the selfish ends of an individual or a small group are placed in the balance that we rise to violent protest." Our answer is this: Strike hard at the evils which make such abuses possible, but do not sit stubbornly by, refusing progress until all things are as they should be. Yield no vital point, but do not forget that almost invariably human achievement has been step by step—most rarely by single bounds.

In what has preceded, we have sought no belittlement of idealism. We recognize it as the very essence of progress —nowhere more truly so than in the field of city planning. But that idealism which refuses to recognize the materials and conditions with which it must work will achieve but little where it might achieve much. For progress there is no exclusive choice between expediency and idealism.

National Forest Policy to Promote Reforestation.—Legislation for a national forest policy in order to promote reforestation, was recommended at the annual convention of the American Paper and Pulp Association by its committee on forest conservation. General recommendation for a national forest policy, to be co-ordinated with state legislation, include: Permanent annual appropriation of $1,000,000, to be applied only where the states co-operate; annual appropriation of $500,000 for forest surveys and land classification; permanent annual appropriations of $1,000,000 to acquire land suitable for timber growing; and permanent annual appropriation of $1,000,000 for forest planting operations in national forests.

Canadian Government Research Laboratory Proposed.—Plans for the establishment of a National Research Institute for Canada are before the Commons Committee on Scientific Research. It was recommended that a site of at least 50 acres should be secured near Ottawa and a building of a laboratory type, four stories in height, to cost $600,000, should be erected. Scientific instruments required would cost approximately $100,000, and salaries would require about $100,000 per annum. This institute would be similar to the Bureau of Standards at Washington and the Mellen Institute at Pittsburgh.

A. A. E. Has Over 16,000 Members.—The membership of the American Association of Engineers on April 15 was 16,007.

Broad Principles of Drafting Department Administration

In the October, 1919, number of "Industrial Management," Mr. Fred D. Hartford, Mechanical Engineer, The Western Chemical Manufacturing Co., presents an article on "Industrial Drafting Room Management," which should be of peculiar interest to drafting room heads, their superiors, and associates. The discussion is of such value that it is reprinted here in full:

The work of the engineer demands at nearly every step designs and drawings; often most of the strictly technical part of his work ends here. The work demands of the engineer that the drawings embodying the correct ideas be produced at minimum expense.

The entrance to practical engineering in a majority of cases is through the drafting room. This is shown by the fact that 75 per cent of the "Positions Vacant" in the columns of the technical journals call for draftsmen, and virtually all others imply the need for familiarity with drawings. Thus, the young engineer comes to regard drafting room experience as a necessary part of his training. Rarely, however, does he aim to end his professional career only as a designer or draftsman. The problem of the employing engineer or his chief draftsman has thus become twofold. First, the drawings must be produced at minimum cost. Second, the draftsmen must be trained for better positions, preferably in the same organizations, and passed on to these positions with their enthusiasm in engineering undiminished. It seems that the constructive attitude taken toward the latter part of this problem produces not only the minimum of cost but also boldness and originality in design.

This article does not wish to underestimate the value of proper technique or of forms, filing systems, etc., for the drafting room, all of which have been the subjects of many excellent articles and books. It wishes to impress on the reader that recognition of the value of engineering to industry will come when the drafting room's products, designs and drawings, meet real needs, and its by-products, engineers, are fitted for better positions.

Under proper leadership the engineering department that is irreplaceable because of its technical ability, its enthusiasm and its resourcefulness gets just salaries.

The Drafting Room's Part in an Organization.—An early responsibility of the engineer or chief draftsman is to secure proper recognition of the drafting room he represents.

The president or manager of an enterprise surrounds himself with heads of departments who in theory at least confirm and protect his judgments concerning the good of the plant. The head of the drafting or engineering department, more than any other single adviser of the executive, should bring to bear on problems of internal plant economy the proper data.

The technical features and data of all departments are coordinated by the drafting room and thereby the efficiency of the whole organization is actively conserved. This direct connection of the drafting room with profits should not be allowed to pass unnoticed even though much engineering work is not spectacular and even though presidents and managers are stressed by other complexities of the business.

Harmonious relations between the drafting room and the construction department are rare when one has the authority over the other. A genuinely scientific attitude rather than an arbitrary one toward points of difference in drawings or construction often puts the drafting room in possession of valuable data or improved methods of doing work. Drawings and construction work are merely means to the production of dividends or public service—the end for which modern enterprise is designed.

Particularly in industry is the drafting room dependent on the operating department for suggestion concerning new manufacturing methods and short cuts, for data on which drawings should be based and for the approval of operating plans of new mechanisms or layouts. The draftsman who is sent out to collaborate with the operating department should be selected as much for qualities which inspire confidence as for ability to take and digest the data. In most cases the engineer or chief draftsman should make the tests himself.

Engineering will gain its proper recognition in an organization when the heads of that department are selected for their courtesy and sense of humor as well as for their executive and technical skill.

Leadership in the Drafting Room.—Maximum production in nearly every undertaking is the result of sustained interest. In drafting room work this interest is vital. True interest in a thing is secured by seeing constantly some new angle or viewpoint relating to it. Proper working conditions, proper working hours, proper vacation periods, increased pay at intervals, all are necessary food for this sustained interest but they are not the reason for its being. If the interest is attained by constructive methods the desired technical skill and accuracy will follow.

Three conditions must be met to secure the draftsman's best interest and enthusiasm. He must have definite information and data covering his work; he must see that his work has a definite value to the plant and he must feel that his efforts are in line with the progress he wishes to make in his profession.

There is no method more certain to discourage a man completely than having him flounder through data or calculations he does not understand and finally having him produce a drawing that must be erased and redrawn half a dozen times. Data, calculations, preliminary layouts and methods should be co-ordinated by the engineer or chief draftsman so that problems assigned to the draftsman are clean cut and definite. Short talks to the group of men concerned in the same problem connecting it with the plant, the industry and engineering in general will very often serve to get the proper interest.

To be of value to a plant drawings must picture parts or devices that fill needs. A mechanism that comes from the drafting room and "works" properly not only increases the interest of the draftsmen in their department but it advertises the drafting room to the other departments in a most effective way. Drafting room work can then be seen to have a distinct value. The pounds of steel saved or the speed or drafting count not at all unless the idea "works" or the parts fit.

Value of Plant Library.—To maintain the connection of the industry with engineering nothing is more valuable than the plant library. For this purpose there should be a comfortable room set apart. The more technical information is made attractive the more will it be used. Books pertaining to the technology, the patents, the history and romance of the industry are necessary. The quota of technical and semi-technical journals covering the activities of the industry and of business in general should be most generous. It may be found desirable to attach to the drafting room standards a list of references to technical literature on the various plant processes. References should be chosen as much for their brevity as for their accuracy.

When the draftsmen realize that their work is vitally necessary, when they know that their ambitions are harmonized with the work in hand to the greatest degree possible, and when they are shown that they are receiving their share of the industry's prosperity, then will come enthusiasm for their department and for their company—enthusiasm that means maximum efforts and maximum results.

Decennial Celebration for the Forest Products Laboratory.—Arrangements are well under way for a big get-together at Madison, Wis., during the latter part of June to celebrate the 10th anniversary of the opening of the U. S. Forest Products Laboratory. It is expected that a large gathering of representatives from the various industries interested in the laboratory's work will be present, and opportunity will be afforded for recreation as well as for becoming more familiar with the extent and significance of the laboratory's activities. Present plans call for a two-day meeting, with addresses by men of national reputation in science and industry, a banquet, tours of inspection through the laboratory, informal discussions, and various forms of entertainment. At the present time the laboratory employs about 200 people and occupies five buildings in whole or in part.

Name Bridge for Its Designer.—The new 27th St. bridge across the northern end of Spring Valley Park at Kansas City, Mo., has been officially named the Ira G. Hedrick bridge. Captain Hedrick, who died while serving in France with the engineering division of the army, was the designer of the bridge and it was the request of the Engineers' Club of Kansas City that the bridge, his last work in his home city, bear his name.

Chinese Bonus System for Commercial Employees

At the end of each year when Chinese firms have their balance sheets made up showing profit or loss, commercial employes get their respective shares of the profits if there are any. During the year, the employes of a small grocery store as well as the employes of a big bank look forward to the coming of the New Year, because it is then that they will get their rewards according to their merits. In China the bonus paid to the employes by the business concerns is very liberal, apparently much more so than that paid to the employes by American or European concerns. Sometimes an employe will get a bonus, the amount of which will exceed the total amount of salary he has received during the year. For instance, a manager of a Chinese native bank only gets from $25 to $30 a month in salary. But if the bank makes money, his bonus at the end of the year will run up to several thousand dollars. The bonus system in China is so liberal that all employes in a firm always work together. The employes in a Chinese firm are very seldom divided in their opinions regarding the business policy. Every employe is loyal to the firm he is serving, because when he looks forward to get a handsome bonus, the firm's interests coincides with his own. As a result, the business secrets of a firm will never be disclosed to outsiders.

The following illustration of the working of the bonus system generally in use in China has been furnished by Mr. K. P. Wang, Finanial Editor of the Shanghai Journal of Commerce:

Suppose a balance sheet of a meat and fish market at the end of the year shows a profit of 15,000 Taels; 10,000 Taels is declared as dividends for the stockholders; 1,000 Taels is declared as reserve fund for the firm, and the remainder 4,000 Taels will be divided among the employes as their bonus. The sum will be divided into 40 parts, the employes will get their parts, varying in accordance with their ranks and merit. The following is the scale generally used:

Manager	16 parts	1,600 taels
Vice manager	4 parts	400 taels
Sales manager	4 parts	400 taels
Accountant	2.5 parts	250 taels
Supply manager	2.5 parts	250 taels
Assistant accountant (2)	3 parts	300 taels
Shroffs (4)	6 parts	600 taels
Cashier	1 part	100 taels
Clerks	1 part	100 taels
Total	40 parts	4,000 taels

The apprentices and the messenger boys get their parts of bonus, too; but their parts are not represented on the official scale. Sometimes the manager will put aside one of his parts for them; sometimes the stockholders give them small sums for reward. In this way, all the employes of the firm get their share. Everybody will feel satisfied; when another year comes, they will work for the firm with additional energy and loyality.

However, the above scale is not universal. There are varieties of scales, as follows:

a. The bonus system as used by Shanghai commercial houses:

Stockholders' dividends	10 parts
Reserve fund for the firm	1 part
Manager	1 part
Vice manager	1 part
Other employes	2 parts
Total	15 parts

b. The bonus system as used by Shanghai native banks:

Stockholders' dividends	10 parts
Manager	1.5 parts
Vice manager	1 part
Other employes	2.5 parts
Total	15 parts

c. The bonus system as used by Hankow native banks:

Method I:

Stockholders' dividends	8 parts
Manager	1 part
Other employes	1 part
Total	10 parts

Method II:

Stockholders' dividends	7 parts
Reserve fund	.5 part
Manager	1 part
Other employes	1.5 parts
Total	10 parts

d. The bonus system as used by the Youngkow oil dealers:

Stockholders' dividends	10 parts
Chief manager	1 part
Assistant manager (2)	1.6 part
Third assistant manager (2)	1.4 part
Accountant (2)	1 part
Oil keeper	.5 part
Property keeper	.5 part
Total	16 parts

The Expense of Estimating*

By HENRY K. KOLSMAN,
President, Illinois Chapter of the A. I. A., Chicago.

Architects have realized for a long time that there is a tremendous amount of waste in the present method of making up estimates. The burden is said to be borne by the contractors, but as a matter of fact the contractors as a whole must pass it on to the community, and the architect is justified in co-operating with you to eliminate that waste as soon as possible, on the ground that it would eliminate an unnecessary charge against the community. When the architect fails to take off the quantities for a job before giving out the plans to ten different contractors and asking for bids, the estimating that must be done on that one job is ten times more estimating than would have been necessary, so far as quantity is concerned, if the architect had given the contractors a survey of the materials that would be required to be left in place in the building when the building is finished.

Now, the cost of estimating, in our judgment, cannot be entirely eliminated from the contractors' expense. The cost of selling your product, your experience, your ability, must be borne by your trade much the same in contracting as in selling any article of merchandise.

The situation of the buyer in the building field may be summed up as follows. Presumably the owner has gone to the architect and has had the architect map out the plans and specifications for approximately the kinds of material he wants to get. He then hands these plans and specifications to the contractor for his experience in estimating and for putting together a structure so that it can be used efficiently. In that case the owner has set down the kinds of materials that he wants, and has presumably paid for that much of the cost of selling as distinguished from the prices ordinarily employed in the commercial world.

But he still falls a little short in our estimation. He gives the contractor plans and specifications laid out in the general way, but he might have gone into the estimating end of the matter and given the general contractor a quantity survey of the plans and specifications, which would make it much easier and less hazardous.

Conclusions of Joint Conference on Payment for Estimating.—It is with that thought that the Joint Conference on Payment for Estimating Construction Work, which is composed of a committee of your organization, one from the American Institute of Architects, and one from Engineering Council, formulated the resolutions that I shall now take up. Two meetings were held by the Conference, at which the subject of the expense of estimating was discussed at great length. The first section of the resolutions adopted is as follows:

> Whereas, There is great economic waste in the present usual methods of individual estimating of the same quantities by several different bidders on the same project; therefore, be it
>
> Resolved, That the following are the conclusions of this conference:
>
> First, That any system of duplication of effort in estimating, wherein each bidder separately estimates the quantities, should be condemned.

There are many reasons, which you know better than I, why such methods of estimating should be condemned. But what comes to my mind just now as most important is that the largest part of the great variation in bids often found on a structure is not due to the difference in prices that contractors place on materials, but instead is due to the variation in the estimates of the quantity of material and labor that would be necessary to carry out those plans and specifications.

Then, if there is an average of ten bidders on one job, or if every contractor on the average must bid on ten jobs to get one, manifestly there is ten times as much effort expended as is necessary. It is also manifest from our point of view that if the quantities for the job were taken off in a systematic manner that would be by necessity universally adopted by the contractors, and if the quantities were taken off under the supervision of the architect who makes the tracings and the specifications, the quantities then would be more apt to correspond with what is expected by the architect than if they were taken up by some individual who never saw the tracings and specifications before.

If it is specified that all shall bid on this bill of quantities, or on this quantity survey and none other, they all have at least one common thing fixed. Under the present method, each bidder may submit a proposal on a different schedule, based upon the way in which his estimates have interpreted the plans and specifications, and upon the care taken to include everything called for.

Quality Survey and Additional Payment for Estimating.—The second section of the resolutions is as follows:

> All competitive bids should be based upon a detailed schedule of quantities prepared from a survey of the plans and specifications, and submitted therewith, the costs of the preparation of such survey of quantities to be borne by the owner.

The only comment that I have to make on this is that we all agree that if the buyer, the owner, is going to go to the trouble of having the plans and specifications prepared, it is logical that he should go further and get a comprehensive estimate for the bill of material or quantity survey that could be easily priced.

In considering the value of a quantity survey, we realize that it will be necessary gradually to work out a standard practice. Quantities must be so listed that the bidder, when he uses them in preparing his bid, along with the plans and specifications, can understand just what will be needed, and can judge accurately as to the labor cost of the work.

The third part of the resolution bears upon payment for pricing the work:

> While the owner should furnish a quantity survey as the basis of bids and contracts, and should submit them with the plans and specifications, and should pay for the same amounts to the bidder the bidder should make no charge to the owner for submitting proposals based on said plans, specifications and quantity survey.

While the owner should furnish a quantity survey, as a basis of bids to contractors, we do not feel that, in addition to this, he should pay each contractor for pricing the quantities and for the various items of overhead that bidding or projects entails.

There is undoubtedly an economic gain resulting from the preparation of a quantity survey by only one individual or institution instead of by five or ten as the case may be, provided these quantities are guaranteed to be correct enough for bidding purposes. Even if the quantity survey says that there is less material required by the plans and specifications than will be necessary, so long as it affords an equitable basis for building, it has served its purpose in a large measure. Adjustment of the contract price may be made to correspond to actual conditions, either before the contract is signed or as the work proceeds.

But when the owner and buyer has gone that far, he says, "This will do for the basis of bidding; here is something that you can give us your prices on. But we feel we ought not to go further as buyer, and so we will not pay you for putting prices on these quantities."

In other words, if we were attempting to say that the owner should pay a contractor for his trouble in figuring up his prices and bidding, we would be going too far. The accepted principle in commercialism is that the cost of selling a product be added to the price charged the buyer, but only in case he does actually buy. Our first step is to say, then, that bidders should make no charge to the owner for submitting prices on his building project, provided the quantities are furnished.

In the last section of the resolutions, an alternative is proposed whereby each contractor would receive pay for his estimate if he had to prepare his own quantities.

> In general, competitive bids should not be invited nor submitted on projects, the plans and specifications for which are not accompanied by a quantity survey, unless the owner agrees to pay a predetermined fee to each bidder for preparing the quantities and submitting an estimate.

This clause, I think, was finally determined upon as a suggestion of co-operation between the builders and architects by way of helping to get the thing established.

Now, you see, if we could agree upon these principles, and have it recognized that they are just and fair to the contractor and the architect, and have them widely known, we could accustom those interested to the idea that unless the plans and specifications are complete, and include a quantity survey, they are not yet ready for bids. This would mean a long step towards reducing some of the errors in bidding and the estimating expense under the present method of bidding.

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*From an address presented Feb. 19 before the Building Contractors' Division of the National Conference on Construction of the Associated General Contractors.

The Preface of a Technical Book

By R. FLEMING,
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"The Preface is that portion of the book in which the author usually explains his purpose in writing it; where he outlines his method of treatment of the subject, and gives credit for his material to whom credit is due." Frost—"Good Engineering Literature."

It is more than this. In the Preface the author brings himself into touch with the reader. He reveals his personality. He states views and opinions which he thinks should be emphasized.

The elder Disraeli in an article on Prefaces writes: "In the first place I observe that a prefacer is generally a most accomplished liar. . . . Prefaces are indeed rarely sincere. . . . Has accident made some ingenious student apply himself to a subordinate branch of literature, or to some science which is not highly esteemed, look in the preface for its sublime panegyric. Collectors of coins, dresses, and butterflies have astonished the world with eulogiums which would raise their particular studies into the first ranks of phiposophy."

These lines may have been true in the eighteenth century when Disraeli wrote them, but it would be an insult to apply them to writers of today—especially to technical writers. But in an earlier article on Prefaces Disraeli wrote, "A Preface, being the entrance to a book, should invite by its beauty."

The dictionaries draw a distinction between the Preface and the Introduction: the former being "commonly explanatory of the object and scope of the work, of methods of treatment, sources of information, and the like," while the latter "contains matter similar in subject and additional to or leading up to what follows." This distinction, however, is not always followed.

The Preface should by no means be passed over lightly by the technical reader. That it may be well worth his attention is shown by the following extracts:

"The books we have studied and mastered in school and college are the ones to which we afterwards, in practice, most readily refer for advice and assistance. It is surely, then, no objection that such books should give a complete view of the whole ground, rather than a short and meagre presentation, which can have but a transitory value in merely introducing the student to the subject, and which often lead him to suppose that there is but little more of it worth knowing."—Translator's (DuBois) Preface—Weisbach's "Mechanics of Engineering," 1877.

"The public hears a great deal of Blue Books, of their dullness and heaviness; nevertheless they contain many curious facts, the germs of new laws. They give information of new discoveries; they are official records of the complaints of society; they gather from all quarter illustrations of the evils which Parliament is asked to remedy; they almost invariably refer to what is novel, and are very often the first authentic accounts published of the actual progress of society, or the formation of those new phases with which it is the duty of legislation especially to deal."—Page following Title of "Catalogue of Parliamentary Papers, 1801-1900." London.

"In order to obviate the necessity of continually quoting the authorities for the various facts and investigations employed in the work, by which the text would have been encumbered or the margin loaded with notes, a list of works that have been most frequently made use of is subjoined. In some cases, where the investigations are copied without alteration, or when they are not complete, the passage of the author quoted, is expressly referred to in a note. This list of authorities is far from complete; to have made it so would have appeared rather as a parade of research, than as a security from the charge of quoting without proper acknowledgment; it has therefore been principally confined to those writers whose labors have not become in some measure the common property of all who follow them in this department of science."—Preface to Renwick's "Elements of Mechanics," 1832.

"There is no table of errata, because no errors are known to exist except two or three of a single letter in spelling; and which will probably escape notice."—Preface to Trautwine's "The Civil Engineer's Pocket-Book." First Edition 1872.

"The printing of the present volume began in August, 1885; and it has gone on at irregular intervals during the 19 years since that time; in a manner which I am afraid must have been exceedingly inconvenient to the printer."—Preface to Lord Kelvin's "Baltimore Lectures on Molecular Physics."

"It is not everyone like Brunel can congratulate his employers upon the falling of a bridge, on the score of its preventing the erection of a hundred more on the same plan. With us the fall of one would be "the hoisting of the engineer with his own petard." The recent calamity at Lawrence (Mass.) cries out in thunder tones against the merciless destruction of life, and most painfully shows that too much care or skill can not be exacted of our constructors.—Translator's Introduction to Morin's "Mechanics." 1860.

The "Square Deal" As Solution of Industrial Relations Problems of Contractors*

By J. H. ELLISON,
Winston Bros. Co., General Contractors, Minneapolis, Minn.

The problem of industrial relations as it affects the general contractor is substantially that which confronts all of the various groups of employers and employes. It seems to some to be extremely complex and difficult of solution; to others it is simplicity itself. Probably the truth lies somewhat between these extremes.

Must Agree Upon Fundamental Principles.—In my opinion, one of the immediate necessities is the clearing up of the fog which has been thrown around the question by presumably well meaning but untutored industrial physicians. We must work from and with fundamental principles, and until the great majority of us can agree upon those fundamentals there is little hope of any solution which can be at all permanent or more than temporarily satisfying.

Let me state some of those principles as I see them. First, no movement nor structure can hope to endure which has not a proper foundation; the only proper foundation for a work of this nature is a spirit of righteousness, or as Theodore Roosevelt phrased it, "The square deal." No enduring adjustment of our social, industrial and political differences can be made between factions who attempt such adjustment in any spirit other than that of fairness. Second, the standard of measurement of human success in life which is based on the amount of property which one has accumulated, is grossly inaccurate and consequently false; the true standard is based on one's contribution to the general welfare of the community rather than on what a person has appropriated from it for his individual and selfish use.

Third, work is not a curse; in fact, the principal source of happiness in life is productive energy intelligently and faithfully applied in every channel of human endeavor.

If all men and women can be brought to recognize these truths, practically as well as intellectually, a giant stride will have been taken toward the permanent disposition of all of the matters in controversy between those employed and those who employ.

Application of Basic Principles.—It is axiomatic that a principle is of no practicable value except as applied to the work in hand. How shall the contractor-employer make application of these alleged fundamentals?

First, the iron hand of authority should be enclosed in a padded glove; employes should be made to feel that rules are made and instructions given because they are reasonable, carefully considered from the point of view of the welfare of the whole, and necessary for the successful prosecution and consummation of the job to be done.

Second, in so far as it is possible, the personal relation with all employes of the man or men who direct the activities and frame the policies of the firm or corporation should be more intimate. Managing officers must know that the mental attitude as well as the specific activities of superintendents and foremen are in accord with the policy of the management.

Third, every indiviual, from the highest officer down through the list to the water boy, must be saturated with the spirit of efficient service. The thought that nothing less than one's best will satisfy the requirements must be as nearly as possible universally accepted. This spirit can be encouraged by the adoption of a reasonable system of rewards for meritorious service.

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*From an address presented Feb. 18 before National Conference on Construction of the Associated General Contractors.

No hard and fast rules for the operation of such a system can meet the demands of all kinds and conditions of work and men; each job brings its individual problems and each employing group will have its individual method of approach and solution. It is scarcely possible to stress too strongly the importance of loyalty in maintaining mutually satisfactory relations between employer and employe. Do not forget that the obligations of loyalty rest with equal force upon both parties. The necessity of loyalty to the interest of the employe rests just as heavily upon the employer and is just as necessary to his success as it is that he should have the loyal co-operation of his wage earners.

Collective Bargaining.—To certain groups, the so-called principle of collective bargaining seems to be the panacea; others maintain that the industrial millennium will promptly follow the concession to the employes of a voice in the management; still others believe that a genuine system of profit sharing will bring complete industrial peace and harmony; and yet another fraction contends that only by a wise application of all of these methods can we reach the desired haven.

If by the term collective bargaining we intend to designate a system whereby the employes of any concern may deal with their employer as a group rather than as individuals, few, if any of us, will object to a trial of principle. There must, however, be certain conditions precedent to such an arrangement before it can hope to succeed. The group must first reach a substantially definite and unanimous agreement as to what they want. Having come to such agreement, as to what willing to accept the responsibility which attaches to the group or association idea and to submerge individual conceptions of what is desirable to the composite conception of the whole.

Bargaining implies a trade for the mutual advantage of both parties to the transaction and entails the responsibility of living up to the terms of the bargain. In business life, a contract can be legally voided only by proof of a violation of its terms on the part of one of the parties to such contract, or on the proof of fraud or deception on the part of one of the parties at the time when the contract was made. In either case, the injured party may legally recover from the offending one to the extent to which damages may be proved to have been sustained. It seems improbable that any type of collective bargaining can or will be generally effected before both parties are willing to accept the financial responsibilities which attaches to a breach of contract and to provide by some means the necessary financial strength that will make it possible for the offending party to satisfy such damage as may be found to have accrued.

It is, and of right should be, generally conceded that the successful management of any business requires both native ability, adaptability to the particular kind of business in hand and special training in the technical knowledge required for the proper conduct of the business. It is my opinion that management has generally given in the past, and will continue in the future to give a voice in the management to employes as rapidly as, and to the extent that such employes develop and display the necessary knowledge and ability to contribute to the successful prosecution of the enterprise. Beyond this point, intelligent beings will properly decline to follow the idea and in this I include those who are employed as well as those who employ.

Profit Sharing.—Profit sharing, in some form, has been in operation in many lines of industry in the past and doubtless will continue to be attempted in the future. Some plans of this nature seem to have been successful, at least in part, and new attempts in this direction are being made. It is my opinion that only such plan as confers upon the sharer his proportion of responsibility and which of necessity implies his willingness to accept that responsibility will be accepted as just and logical and that only under that condition will any such arrangement become at all permanent.

One of the first essentials of satisfactory industrial relations is that the business itself must be sound and of value to the community, that the principles which governed its organization and which direct its operation are just and that their enforcement is continuous and honest. It is my observation, through a good many years of experience, that few employers are cunning enough to "put anything over" on their employes for any length of time without ultimately coming to grief, to an extent which prohibits any further attempt in that direction.

Close attention to the education of all employes in the proper understanding of the requirements of the business and of their special function in that business will always prove a good investment. That education must, however, be carried on as between friends in a spirit of helpfulness and in some cases requires infinite patience on the part of the instructor. The mental processes of many men of real ability are slow, and time is required in which to digest a thought or principle. In such cases, the idea once assimilated, sticks.

Seasonal Employment.—A feature of the problem which is of peculiar interest to contractors is that of continuous employment. In many cases, our work is of such a nature that suspension during a portion of the year is almost imperative. The necessities attendant upon existence—food, clothing, etc.—do not cease with the advent of winter. Men who depend upon wages for their supply of these needs must have the means of supply provided in some manner. The payment of a sufficient wage during the working period to enable the wage earners to lay by enough to carry him over the inactive season is one method but is not wholly satisfactory. A better plan would be to diversify activities so that a substantially uniform force can be maintained throughout the year whenever and wherever possible. Where this cannot be done, is it wholly impracticable to carry all useful employes on the pay roll on part time or on some other mutually satisfactory basis during the period of necessary inactivity? I realize that there are valid objections to this plan. Can anyone suggest one which is not subject to reasonable criticism?

Design and Erection Features of Steel Transit Sheds at Halifax Ocean Terminals

Two of the permanent transit sheds, Nos. 21 and 22, forming a part of the Canadian Government's ocean terminal development at Halifax, N. S., have been completed recently. An excellent description of this work is given in The Contract Record by J. Robertson of the Erection Department of the Dominion Bridge Co. In his article, an abstract of which follows, Mr. Robertson has furnished all necessary designing data, particularly the assumed weights and loads. Information of this kind is all too scarce.

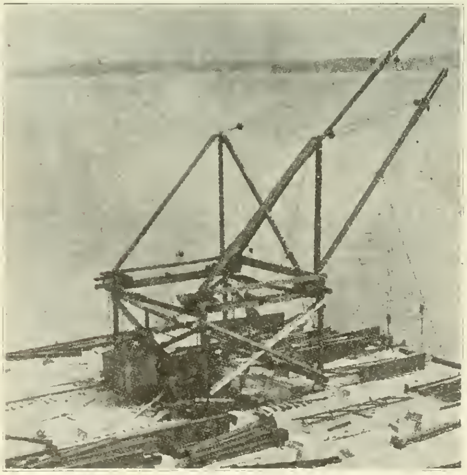


Fig. 1—Erection Traveler, Consisting of Two 12-Ton Stiff Leg Derricks on Timber Framework.

The two sheds have a total length of 1,210 ft. in 22-ft. longitudinal panels and consist of four main rows of columns forming three transverse bays. The centre bay is 33 ft. wide and the two side ones 27 ft., giving a total width of 87 ft. from center to center of columns. Half way down the building five panels are utilized to give a central office building providing accommodation for the steamship companies, custom officers, etc.

Figure 2 shows a typical cross section of both sheds, the overall height being about 52 ft. All heavy cargo will be handled on the ground floor, while the main floor will be devoted to the use of passengers and the sorting out of their baggage. This made it necessary to lower the roof trusses in the bay next to the harbor about 9 ft. and to make them strong enough to carry the conveyor belts and machinery.

Design of Steelwork.—In designing the steelwork the following loads and unit stresses were used:

Roof:—Dead and live.....	50 lb. sq. ft.
Purlins	5 lb. sq. ft.
	55 lb. sq. ft. on purlins.
Trusses	5 lb. sq. ft.
	60 lb. sq. ft. on trusses.

Horizontal wind on all vertical surfaces 30 lb. sq. ft.

Siding —Corrugated sheathing plastered with concrete 2 in. thick, giving a total weight of 30 lb. sq. ft.

Doors:—10 lb. sq. in.

Floor Loads:—Grain gallery D + L	= 100
Steel	= 10
	110 lb. sq. ft.
Main Floor:—Concrete	100 lb. sq. ft.
Beams	10 lb. sq. ft.
Live load........	600 lb. sq. ft.
	710 lb. sq. ft. on beams.
Girders	15
	725 lb. sq. ft. on girders.
Trolley Beams:—Dead	5,000
Live	6,000
Impact	3,000
	14,000 lb. concentrated moving load.
Unit Stresses:—Tension	16,000 lb. sq. in.
Compression	16,000—70 l r lb. sq. in.

When considering wind stresses alone, or in combination with dead and live load stresses, 25 per cent was added to the allowable unit stresses, provided that the section found was not less than that required if wind were neglected.

Bearing on Foundations;—500 lb. sq. in.

The unusually high live load of 600 lb. sq. ft., which had to be allowed for on the main floor, made the steelwork of a very heavy nature. Bethlehem shapes were used for all the columns, the bottom sections ranging from 14 in. at 91 lb. to 14 in. at 178½ lb. with a maximum load of 609,000 lb., while the top sections were 10 in. at 49 lb. and 59½ lb. with a maximum load of 137,000 lb. A typical girder in the main floor had the following cross section: one 60 in. x ⅜ in. web, two 6 in. x 6 in. x 11/16 in. flange angles, one 14 in. x ½ in. cover plate and one 14 in. x 7/16 in. cover plate with floor stringers of 27 in., 90 lb. I's framing into it.

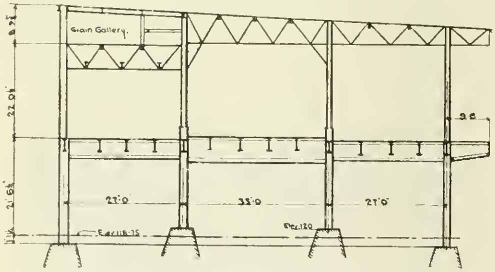


Fig. 2—Section of Sheds Showing Nature of Framing.

Two Derrick Erection Traveler.—The heaviest piece to be erected weighed 9 tons and as the peak of the building was about 60 ft. from the ground level, an erection traveler was designed to meet those conditions. This is shown in Fig. 1. It consists of two stand 12-ton stiff-leg derricks mounted on a framework of timber. This framework was 37 ft. wide by 33 ft. long and 20 ft. high, 12 in. x 12 in. timbers being used for the sills and uprights and 10 in. x 3 in. planking for the bracing. Two 30 hp. double drum hoisting engines were located on a floor at the rear and served the double purpose of supplying power and acting as a counter-weight. A small office was also built on timbers cantilevered out, for the purpose of keeping erection plans, small tools, etc., always handy at the point of erection. The whole was mounted on four double traveler trucks and traveled backwards on two rails laid 37 ft. c. to c. The booms of the derricks were 11 in. x 14 in. x 60 ft. long with two channels bolted on the end to act as an outrigger for a single whip, run off the nigger-head. This saved a great deal of time in erecting all the small pieces and gave the derricks a larger radius as well.

Early in the summer the Canadian National Ry. installed a standard gage track along one side of the building for its entire length, and this was used as a service track. All the steel was delivered by rail and a 20-ton "Industrial" crane unloaded it from the cars and distributed it systematically into piles of similar pieces. This proved to be a great benefit and a large saving was realized both in time and money, by not having to search all over the site for a certain piece when required.

100 Tons Erected Per Day.—Preliminary work was commenced at the site in July, 1919, but the actual erection did not commence until Sept. 3rd. Before starting erection, all the column foundations were carefully checked for level and line and brought to exact grade with cement grout put on by expert cement finishers. This ensured the columns having an even bearing on the concrete, saved the large amount of plumbing usually necessary to bring the steel to line, and enabled all field connections to come properly and easily together. The main steelwork was erected by Nov. 3rd, with an average gang of 50 men per day on the job. Owing to the very exposed nature of the site and the lateness in the year, 18 days were lost in this time on account of high winds and rain. This makes the actual erecting time about six weeks, and gives an average of 100 tons erected per working day. Trouble was also experienced by the sand drifting into the journals and bearings of all the machinery causing undue wear.

The field riveting was started on Sept. 22, air being supplied by a portable 8 in. x 12 in. steam driven straight line compressor. There were approximately 126,000 field rivets driven and it took 141 railway cars to convey the 3,600 tons of steel work to the site.

The general layout of the sheds was arranged in the government offices at Moncton, N. B., under the charge of Mr. W. A. Duff, Assistant Chief Engineer. The steelwork was designed, fabricated and erected by the Dominion Bridge Co., Lachine, Que. Mr. McGregor was the government's superintending engineer in Halifax and Mr. Robertson represented the Bridge Company.

Cost of a 3-Story Warehouse

By W. C. HUNTINGTON,

Professor of Civil Engineering, University of Colorado.

In the fall of 1919 contracts were signed for a 3-story warehouse located in Denver, Colo. This building is now nearing completion. The building is of steel cage construction with intermediate beams of 8 in. x 18 in. douglas fir located at the third points of the girders. The floor consists of heavy timber with oak slip tongue and a maple wearing floor. The foundations are concrete and the exterior walls brick laid in cement mortar. On two sides these walls are carried by the steel framework, the remaining walls being bearing walls. The roof is 5-ply tar and gravel on 2-in. matched sheathing. A portion of the first floor is devoted to a display room with tile floor. Plate glass windows are provided on two sides of the building in the first story. There are eight offices on the second floor, the remaining portion of the second floor and the entire third floor being used for storage of light electrical equipment. The basement extends under the entire building and has a concrete floor.

The building is heated by the vapor steam system and is protected from fire by a Grinnell sprinkler system.

One passenger and one freight elevator are provided.

Provision is made in the foundations, columns, walls, and roof girders for the addition of a fourth story.

The total cost of the building was 21 ct. per cubic foot distributed as follows:

	Per cu. ft.
Excavating, brick and stone	$0.043
Heating and plumbing	.020
Carpenter work	.073
Electric wiring	.003
Plaster and concrete	.009
Painting	.005
Elevators	.010
Sprinkler system	.012
Tile floors	.005
Steel	.030
Total cost	$0.210

All work was done by contract. Carpenters were paid $8 per day, bricklayers $9, plumbers $9, and common laborers, $4.

The G. W. Huntington Architect Co. was architect for the building and the structural design was done by the writer.

Concrete in Building Construction According to Various Building Codes

A real and unusual criticism of building codes was brought out by Mr. Fred W. Lumis, Building Commissioner of Springfield, Mass., in a paper presented at the recent National Conference on Concrete House Construction. In connection with his paper, Mr. Lumis submitted the accompanying resume of 15 typical existing codes, reduced to their simplest form and containing only the requirements pertaining to concrete. Commenting on these codes, Mr. Lumis said:

In considering the codes, it will be observed that the requirements are general and not specific; alike to the warehouse—1,000 ft. long, and to the cottage—with partitions serving as diaphragms, extending in all directions, tying and bracing the whole structure every few feet.

The vertical supports and walls in large structures are designed principally with respect to their compressive strength, but the designer of a concrete house is not permitted to utilize any such economies.

As an illustration, a good reinforced concrete house, having horizontal dimensions of 30 by 40 ft. and an average height above the basement of 20 ft., would weigh, including outside walls, floors, partitions and roof, approximately 150 tons, and if all the floors were loaded to their full carrying capacity of 40 lb. per square foot, it would add about 50 tons more. The weight of the whole building above the basement, together with its live load, could be safely supported upon one well designed concrete column 23 in. in diameter. In the vertical supporting members in a typical concrete house there is material sufficient to make 25 such columns.

Now this is extravagant designing, an unnecessary waste of valuable material. The designers are not encouraged to apply their inventive genius, or even the best of their training and experience, but in many cases are restrained and handicapped by the requirements of existing building codes, codes that are influenced by other codes, which in turn are influenced by older and different methods of building. There is no logical reason why concrete construction should be measured in multiples of 4, 8, or 12 in., just because brick and stone are figured that way.

To begin with, Portland cement concrete is a comparatively new material, and new uses for it are being discovered every day. Until very recently, the concrete house was designed on the same lines and with the same details as a brick or stone house. And it was but natural that existing or incongruous building regulations should be applied to it.

RESUME OF 15 BUILDING CODE REQUIREMENTS FOR CONCRETE.

City	Steel Stresses per sq. inch		Concrete Stresses per Sq. Inch			Concrete Mixture	Thickness of Walls	Miscellaneous
	High Carbon	Mild	Extreme Fiber	Compression: Mass Concrete	Compression: Columns			
Boston	16000		500	350	600 vertical and hooped rein.	1.2 4	Basement—12" 1st and 2d stories—8"	May use cinders in floor slabs, roof or filling
Bridgeport	16000	14000	600	450		Must Withstand 2000# at 28 days	Not less than 12" or same as brick	Slag or clean furnace clinkers permitted
Buffalo	16000	16000	500	350		1·2 5	Same as brick	
Chicago		18000	35% of ultimate crushing strength	20% of ultimate crushing strength		1.1·2—2900* 1 1½.3—2400 1 2 4—2000 1 2½.5—1750 1·3:7—1500	Same as brick	Cinders permitted except in bearing walls, columns or piers
Cincinnati	16000	16000	600	500		1:2½·5	Reinforced — not less than 4" Reinforced basement walls—12" 1st and 2d stories—8"	Cinder concrete in floor arches or slabs only
			700	600		1 2 4		
			800	700		1 1½ 3		
Detroit	18000	16000	650	450		Walls, beams and floor — 1 2.4 Columns 1 1½ 3	Reinforced—66% of that required for brick Plain—Same as brick	Slag permitted in walls and slabs. Boiler cinders prohibited
Hartford	80000 (ultimate)	60000 (ultimate)	800	500	850 hooped rein.	1 2 4	For houses. Basement — 12" 1st and 2d stories—8"	1 2 4 cinder concrete allowed at 50% of values given.
Los Angeles	16000	16000	650		800 hooped rein	1 2½ 3½ crushed rock	Reinforced — not less than 8" Plain and block—same as brick	
			520	350		1:3.4½ screened gravel		
				250 no rein.		1:7 bank or river gravel		
Louisville	16000	16000	650	650	450—vertical rein. only 540—hoops only 650—1 to 4% vert. rein. and hoops	1.2 4	12" 1st story of one-story bldgs.—9" Hollow block—10% less than brick or monolithic	Cinder concrete prohibited for construction work or fireproofing
Minneapolis	16000	16000	650	500† 208‡		1 2 4—must stand 2000 #	Basement — 12" 1st and 2nd stories—10"	Cinder concrete not considered
New York	20000	16000	650	500 (plus 900 on vert. rein.)		Reinforced—1 2 4—must stand 2000 # at 28 days. Plain—1 2½:5	Basement (rein.)—12" 20' walls—8" 1st 10' of 30' walls—10"	Cinders permitted in floor slabs, reinforced partitions 4" thick and plain partitions 5" thick
Philadelphia	16000	16000	650 300 for cinder concrete	500 Plain walls or large piers —250		1:2·4— must stand 2000 # at 28 days	Reinforced—66% of that required for brick Block walls (1·2 3 mixture)—same as brick	Cinder concrete permitted in slabs and minor partitions—mixture 1:2·5; to stand 800# at 28 days.
Portland, Oregon	16000	16000	650	400			Same as brick	Cinder concrete not mentioned
Rochester	20000	16000	650	650	450 with vertical rein. only	1 2 4 must stand 2000 # at 28 days	Block—basement 12"—1st, 2d and 3d stories—8"	Cinder concrete permitted for floor slabs and fireproofing
St Louis	20000	14000	800	500		Reinforced — 1 2 4 must stand 2000 # at 28 days Plain—1 3 5	Same as brick	Hard burned aggregate—stresses 50% of those for stone concrete

*Crushing values of respective mixtures.
†For 1 2 4 concrete. ‡For 1:3.5 concrete.

Cities differ in detail of inspection and other parts of codes.

Hartford requires that a plant making block material must be in full operation when official tests are made and that the names of the owners of said plant must be placed on file with the Building Department. Block (1 3 4 mixture) must stand 1000# per sq. in. at 28 days. Allowable working load is 90# per sq. in. They require a license to make blocks and the license may be revoked for causes. The same license regulations hold at Portland, Ore., but block must be 1 3 (sand) or 1:3·5 (crushed rock and gravel and must stand 2000# at 30 days.

Los Angeles requires the inspector to stop all work not within the requirements of the ordinances or be subjected to fine and imprisonment.

Minneapolis demands that designers of concrete buildings compute the dead and live loads and indicate same on drawing.

Philadelphia approves of reinforced concrete for all types of buildings whereby the design conforms to the requirements of good engineering practice.

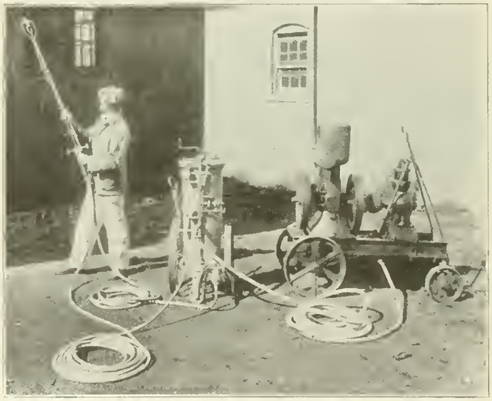
For reinforced concrete New York demands that aggregate be screened crush stone or gravel, but aggregate for mass or plain concrete may be granite, trap rock or gravel.

Rochester, N. Y. demands that the Building Superintendent keep a detailed record of every operation including the date of removal of forms and file record with Building Department.

St. Louis makes no provision for block.

Vortex Paint Spraying Machine

A new paint-spraying machine for painting bridges, structural work, concrete and masonry surfaces and for the general use of painting contractors has been placed on the market by the Vortex Manufacturing Co., Cleveland, O. An important feature of the machine is the nozzle. This has two openings—a central opening for paint and an annular opening around the ceter from which the air is discharged as a veritable blast under a pressure approximating 60 lb. to the square inch. There are separate conduits for air and paint, terminating in a right angle on each side, which forms an axis for the nozzle and permits it to be operated at any desired angle. The paint is driven from the central outlet under low velocity and is immediately picked up by the surrounding air jet and carried to the painted surface. The air jet is too powerful for the paint to penetrate. It works in defiance of wind and gravity and, while there is a small amount of spattering from the surface, this loss is remarkably small; and the whole tendency is to spread evenly rather than to spatter. The manufacturers state that the machine has consistently maintained records of 2,000 sq. ft. per hour or more on plain interior work, where conditions were wholly favorable and the operator experienced in his task, and that it had been quite common for interior painting jobs, sometimes performed by novices, to be accomplished at the rate of 1,000 to 1,600 sq. ft. per hour. In a recent job at the E. 55th St. gymnasium in Cleveland, figures that had been preserved at that time and of the time spent in previous hand painting made a good basis for comparison. Panels 104 sq. ft. in size had been painted by 2 men at an average of 35 minutes per panel for a single coat. The Vortex appliance handled by 1 man did a panel every 5 minutes and the single application equaled 2 or perhaps 3 brush-applied coats in cover.



Assembly of Compressor, Paint Container, Air Pressure Applying Apparatus, Spraying Nozzle and Hose Connections, Etc.

Electrically Welded Steel Framework Meets Requirements of Building Code

The first electrically welded steel structure ever authorized by the building department of New York City, has just been erected by the Electric Welding Co. of America as an addition to its plant in the Borough of Brooklyn. This steel construction has been accomplished without the use of rivets or bolts and with practically no fabrication necessary.

Before the company could proceed with its building plans, it was necessary to obtain permission from the various city building departments, and such permission would only be given if certain tests were made which would satisfy the building officials, that a welded structure would be absolutely safe and would compare favorably in all other respects with a riveted steel framework. Certain samples of welded joints were requested for tests as to strain, compressing and shearing.

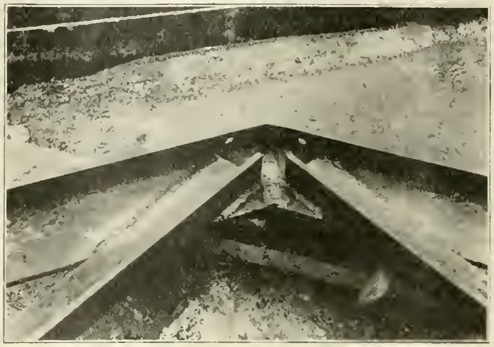
A specific sample of a lap weld of 1¼ in. x ⅜-in. bars, the ends lapped 1¾ in. and welded across the edges, was submitted. This welded sample was put in the machine in direct tension and developed the full strength of the bar as the break occurred in the bar 3 in. above the weld and developed a strength close to 60,000 lb. per square inch without affecting the weld. These welds were cut across, but showed no line of demarkation between the welding metal and the original bar metal.

Test of a 40-ft. Span Electrically Welded Steel Roof Truss.

Another sample consisted of two angles set at right angles and lap welded at the intersection, the 3-in. legs vertical 2x3x⅜. This sample was set in the machine so that there was a horizontal lever arm of 8 in. from the center of pressure to the center of weld and intersection, and developed a beam load of 11,375 lb. at the weld or a torsional stress of 91,000 lb. at the weld with no apparent distress to the weld. The angles buckled to such an extent that they failed to resist pressure.

The tests of these samples were entirely satisfactory to the building officials. Permission was subsequently given to proceed with the erection of the steel framework, but there was still another test to be made of the steel trusses of 40 ft. span, which were to be used to sustain the roof. These trusses were of fan type of design and all members were electrically welded together, no bolts or rivets being used. The trusses were spaced 20 ft. apart, supported by 8x8 H beam columns 19 ft. high; on the sides of these columns brackets were fastened to carry an overhead traveling crane of 5-ton capacity. The weight of each truss was about 1,400 lb.; the top and bottom chords were composed of 4x5x⅜ T-irons, and the struts were 3x2⅜-in. angles; the purlins were 10-in. 15-lb. channels.

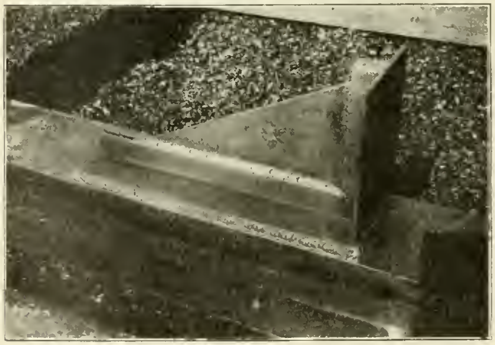
The trusses were designed for a live load of 40 lb. per square foot, each truss supporting a panel of 800 sq. ft. They were tested at a load of 120 lb. to the square foot, or a total load of 48 tons on the two trusses. The load consisted of gravel in bags which were piled in tiers on planking arranged for the purpose.



Welded Peak of Truss.

The readings, taken after the load had been on for 48 hours, showed: East support settled 15/16 in.; West support, ¾ in. actual; Point No. 2, 7/16 in. actual; Point No. 4, ½ in. actual deflection, Point No. 3 9/16 in. actual deflection. Two days afterward the load was entirely removed and readings taken at this time showed all points in the trusses had returned to their original position, leaving no permanent deflection except at Point No. 3 of 1/16 in.

The official report states: "From the above it is evident that electric welding is a dependable method of uniting structural members and is stiffer than riveting if the work is properly performed."



Bracket Welded to Column for Supporting Rail of Overhead 5-Ton Traveling Crane.

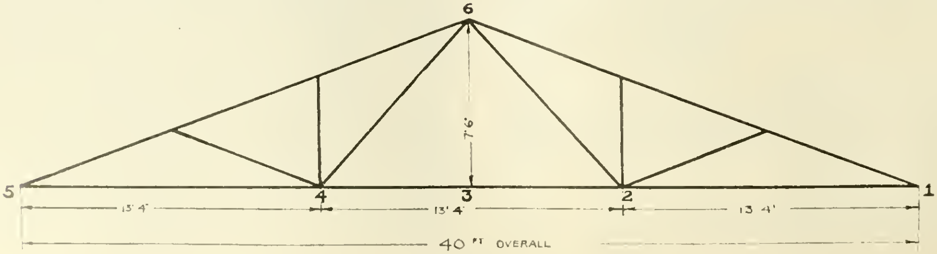


Diagram Showing Points at Which Readings Were Taken in Test of Roof Truss.

Salary Schedule for Engineers in Municipal Service

The accompanying schedule of salaries of engineers in municipal service is the third national schedule for engineers in public service issued by the American Association of Engineers, it having been preceded by a schedule for state highway engineers and another for county highway engineers. The latter two have been endorsed in final form by the board of directors of the association, but the municipal schedule is still in tentative form and is issued now for the criticism of the profession.

The preparation of these three schedules has been under the direction of the committee on salaries of engineers in public service, of which A. N. Johnson, Consulting Highway Engineer of the Portland Cement Association, is chairman. Mr. Johnson and the rest of his committee, with the assistance of a large number of corresponding members, prepared the schedules for state and county highway engineers. The municipal schedule was prepared by a sub-committee headed by S. C. Hadden.

It is expected the schedule will be adopted at the next meeting of the board of directors on May 9 at St. Louis. Meanwhile criticisms are requested and should be sent to S. C. Hadden, 63 E. Adams St., Chicago, before that time.

PROPOSED RECOMMENDATIONS FOR SALARIES FOR ENGINEERS IN MUNICIPAL SERVICE.

Schedule 1—Cities Up to 15,000 Population.

CITY ENGINEER—		
In charge of all engineering work of the city except water works	$3,500	$5,200
FIRST ASSISTANT ENGINEER—		
Duties as assigned; no executive work	2,400	3,000
SECOND ASSISTANT ENGINEER—		
Performs or has charge of drafting and surveying work	1,800	2,400
Rodman and chainman	1,200	1,600
INSPECTOR ON CONSTRUCTION WORK—		
First class	2,400	3,000
Second class	1,200	1,600
SUPERINTENDENT OF WATER WORKS—		
In charge of maintenance, operation and extension of water works system	1,800	3,600
SUPERINTENDENT OF STREETS AND SEWERS—		
In charge of maintenance of city streets and sewers	1,800	3,000

Schedule 2—Cities from 15,000 to 50,000 Population.

CITY ENGINEER—		
In charge of all engineering work of the city, except water works	4,800	6,000
FIRST ASSISTANT ENGINEER—		
Duties as assigned but responsible for office engineering work	2,400	3,600
SECOND ASSISTANT ENGINEER—		
Chief of Survey Party and Supervising Engineer on construction	2,400	3,600
INSTRUMENTMAN	1,800	2,000
DRAFTSMAN	1,800	2,400
RODMAN, CHAINMAN AND TRACER	1,200	1,600
INSPECTOR ON CONSTRUCTION WORK—		
First class	2,400	3,000
Second class	1,200	1,600
SUPERINTENDENT OF WATER WORKS—		
In charge of maintenance, operation and extension of water works system	3,600	5,000
SUPERINTENDENT OF STREETS AND SEWERS—		
In charge of maintenance of city streets and sewers	2,400	4,000

Schedule 3—Cities from 50,000 to 100,000 Population.

CITY ENGINEER—		
In charge of all engineering work of the city except water works	5,500	7,500
DEPUTY CITY ENGINEER—		
Office engineering and special work as assigned	3,200	4,800
DIVISION ENGINEER—		
In charge of surveying operations and supervision of city construction work	3,000	4,500
ASSISTANT ENGINEER—		
Reports to division engineer and acts as chief of party or construction superintendent	2,800	3,600
INSTRUMENTMAN	2,200	3,000
DRAFTSMAN	2,200	3,000
RODMAN, CHAINMAN AND TRACER	1,500	1,800
INSPECTOR ON CONSTRUCTION WORK—		
First class	2,600	3,200
Second class	1,500	1,800
SUPERINTENDENT OF WATER WORKS—		
In charge of maintenance, operation and extension of water works system	4,500	6,000
SUPERINTENDENT OF STREETS AND SEWERS—		
In charge of maintenance of city streets and sewers	3,600	4,800

Schedule 4—Cities from 100,000 to 300,000 Population.

DEPARTMENT COMMISSIONER—		
Commissioner of department of public works or head of special commission as on transportation, sewage disposal, additional water supply or other similar work of the first magnitude	7,500	10,000
CITY ENGINEER—		
In charge of all engineering work of the city except water works	7,000	8,500
DEPUTY CITY ENGINEER—		
Principal assistant to city engineer assigned to special work	4,800	5,400
DIVISION ENGINEER—		
In charge of major subdivision of the city engineering work such as pavements, sewers, bridges, etc.	4,000	4,800
OFFICE ENGINEER—		
In direct charge of design, reporting to division engineer	3,600	4,000
ASSISTANT ENGINEER—		
First grade	3,200	3,800
Second grade	2,800	3,100
Reports direct to division engineer and acts as chief of party, squad leader or construction superintendent.		
TESTING ENGINEER, CHEMIST OR BACTERIOLOGIST—		
In charge of testing work in construction material laboratory, water purification plant or sewage treatment plant	3,200	3,800
INSTRUMENTMAN	2,400	3,200
DRAFTSMAN—		
First grade	2,400	3,200
Second grade	1,800	2,100
RODMAN, CHAINMAN AND TRACER	1,700	2,000

The schedule follows:

INSPECTOR ON CONSTRUCTION WORK—		
First class	2,800	3,400
Second class	1,700	2,000
SUPERINTENDENT OF WATER WORKS—		
In charge of maintenance, operation and extension of water works system	5,000	7,000
ASSISTANT WATER SUPERINTENDENT—		
In charge of domestic distribution system	3,600	4,800
WATER WORKS MECHANICAL ENGINEER—		
In charge of pumping plants of city water works	3,600	4,800
SUPERINTENDENT OF METERS AND SERVICES—		
In charge of installation of water meters, service pipes and meter reading	3,600	4,800
SUPERINTENDENT OF WATER FILTRATION—		
In direct charge of city water purification pjlant	3,600	4,800
SUPERINTENDENT OF STREETS—		
In charge of maintenance of streets, including street cleaning and refuse collection	3,600	4,800
SUPERINTENDENT OF SEWERS—		
In charge of sewer maintenance, repairs and new connections	3,600	4,800
SUPERINTENDENT OF SEWAGE DISPOSAL—		
In direct charge of city water purification plant	3,600	4,800
SUPERINTENDENT OF REFUSE DISPOSAL—		
In charge of municipal refuse destructor or incinerator	3,600	4,800

Schedule 5—Cities from 300,000 to 500,000 Population.

DEPARTMENT COMMISSIONER—		
Commissioner of department of public works or head of special commission as on transportation, sewage disposal, additional water supply or other similar work of the first magnitude	10,000	15,000
CITY ENGINEER—		
In charge of all engineering work of the city except water works	9,000	12,000
DEPUTY CITY ENGINEER—		
Principal assistant to city engineer assigned to special work	6,000	7,500
DIVISION ENGINEER—		
In charge of a major subdivision of the city engineering work such as pavements, sewers, bridges, etc.	4,200	6,000
OFFICE ENGINEER—		
In direct charge of design, reporting to division engineer	3,800	4,200
ASSISTANT ENGINEER—		
First grade	3,400	4,000
Second grade	2,900	3,300
Reports to division engineer direct and acts as chief of party, squad leader or construction superintendent.		
TESTING ENGINEER, CHEMIST OR BACTERIOLOGIST—		
In charge of testing work in construction material laboratory, water purification plant or sewage treatment plant	3,400	4,000
INSTRUMENTMAN	2,400	3,200
DRAFTSMAN—		
First grade	2,400	3,200
Second grade	1,800	2,100
INSPECTOR ON CONSTRUCTION WORK—		
First class	2,800	3,400
Second class	1,700	2,000
RODMAN, CHAINMAN AND TRACER	1,700	2,000
SUPERINTENDENT OF WATER WORKS—		
In charge of maintenance, operation and extension of water works system	7,500	10,000
ASSISTANT TO WATER SUPERINTENDENT—		
In charge of domestic distribution system	4,800	6,000
WATER WORKS MECHANICAL ENGINEER—		
In charge of pumping plant of city water works	4,800	6,000
SUPERINTENDENT OF METERS AND SERVICES—		
In charge of installation of water meters, service pipes and meter reading	4,800	6,000
SUPERINTENDENT OF WATER FILTRATION—		
In direct charge of city water purification plant	4,800	6,000
SUPERINTENDENT OF STREETS—		
In charge of maintenance of streets, including street cleaning and refuse collection	4,200	6,000
SUPERINTENDENT OF SEWERS—		
In charge of sewer maintenance, repairs and new connections	4,200	6,000
SUPERINTENDENT OF SEWAGE DISPOSAL—		
In direct charge of sewage disposal plant operation	4,800	6,000
SUPERINTENDENT OF REFUSE DISPOSAL—		
In charge of municipal refuse destructor or incinerator	4,200	6,000

CITY MANAGERS—

Where a City Manager is employed his position shall be defined as the administrative head of the municipality, appointed by its legislative body, and his duties make him the head of the service, safety, health and welfare departments of the city. The following salaries are proposed for City Managers:

Schedule 1	5,000	7,500
Schedule 2	7,000	8,500
Schedule 3	8,500	10,000
Schedule 4	10,000	12,000
Schedule 5	12,000	15,000

These schedules not to operate to reduce any existing salaries.

Industrial Research in England

Backed by Parliament and many groups of manufacturers and scientists, a great organization for the conduct and supervision of research work has been undertaken in England. The scheme received its parliamentary sanction in 1915, but is still far from perfected. Questions of broad policy were discussed at a meeting held under the presidency of Sir W. McCormick, chairman of the Advisory Council, in the summer of 1919, and attended by prominent men, representative of many different fields of activity. This meeting is reported at considerable length in "Engineering," London, and it is from this source that the following information is abstracted.

The scheme approved (by Parliament) involved the formation of a Committee of the Privy Council, to which was attached an Advisory Council, wisely composed of men eminent in pure science with others equally prominent in the world of industry. Following on the original construction, many industrial associations of manufacturers have been formed under the auspices of the Council, and their cooperation has been both hearty and helpful.

As a consequence of the initial movement, various rival scientific research associations have been set up whose functions are as comprehensive as they are difficult of realization.

The eagerness to start these competing associations suggests that the government scheme has not met with such general approval as was anticipated. Complete concurrence in one scheme was not to be expected, but these separate associations may lessen the authority and divert the attention which should be centered on the main institution.

Four topics engaged the attention of the meetings: (1) The formation of a Records Bureau; (2) The Conditions of Employment of Research Workers by Research Associations; (3) Co-operation Amongst Research Association for the Study of Accessory Materials or Equipment; and lastly, Subscriptions to Research Associations.

Live Intelligence Department vs. Dead Museum.—Mr. Fleming of the British Westinghouse Company pointed out the value to be expected from developments which would originally be merely incidental to the solution of definite problems; and he also sounded a warning of the danger of burying what might be of value under too great a mass of miscellaneous matter.

He urged, however, that activity should not be limited to circulating the bare records of the Research Associations, but that an effort should be made to preserve the incidental, but often valuable, matter that resulted as a by-product from a research investigation, too often lost for the want of some agency to give permanence to this fleeting matter. Mr. Fleming also called attention to the danger of giving too exclusive attention to the accumulation of masses of indirect or incidental features of information. Doubtless the collection of such material from foreign research organizations, or from obscure sources, generally inaccessible to the public, was eminently desirable, "but there is a grave risk in launching out and forming a central bureau, extending to work of this kind, of making it instead of a live intelligence department, really a dead museum."

The relations between different branches of research and between the workers themselves were discussed.

For a long time to come it is to be expected that research will be conducted more and more along lines of solving problems incidental to improved processes and methods, promoting greater efficiency generally, and the research knowledge bearing on such questions is in the minds of men and not in books. Hence the department should assist in promoting intimate contact among research workers.

Secretive vs. Open Policy.—Americans Criticised.—Admitting that many cases would arise in which different trades had a common interest, communications would be essential to prevent overlapping of work; it was therefore of the utmost importance to know what steps the department proposed to take in order to safeguard the interests of the associations who were already disclosing many facts with the view of benefiting the trade concerned. The danger of information deposited with the Bureau reaching the hands of competing companies of different nationalities was not to be overlooked. As a corollary to this remark Mr. Marlow (Boot and Shoe Research) commented on the unwillingness of the Americans to supply valuable intelligence. Information was usually withheld till it was two or three years old, and he suggested that the Records Bureau might be usefully employed in quickening the interchange of ideas and information. Secrecy where necessary could be secured and guaranteed by dividing the Bureau into a confidential and non-confidential section. Communications could be sent to either section, but, if sent to the former, the department would use strict precautions to ensure privacy. Information from the Bureau would be forwarded to others only with the knowledge and consent of the party depositing the information. But sometimes this confidential matter might be of great value to another Research Association, and in that case the Bureau would be prepared to play the part of "honest broker," and negotiate the transference of that information on agreed terms.

Welfare of Research Workers.—This subject was given much discussion. Regarding agreements under which work would be done it was pointed out that the first item of the agreement should be that the investigator be paid such a salary as to relieve him of all family anxiety, otherwise his mental effort is depreciated and he cannot give the best service to the work.

A plan for special awards for achievement was criticised as follows in a letter from the director of a research laboratory: "The payment to people of special amounts on account of successful work creates the worst spirit on a research staff. Firstly, a successful result is hardly ever the work of a single man. It nearly always arises as the result of conversations with, and suggestions from, others. One has known cases where the research man has received all the essence of an idea from a workman, and one can recall few cases in which much help has not come from colleagues. The bestowal of special grants is liable to cause ill-feeling and tends to invite secrecy and exclusiveness. Secondly, the director is responsible for assessing pieces of work to different individuals, and it puts him in an unfair position when he has to give a man a piece of work, which in the nature of things cannot lead to anything for which a special grant could be obtained. I suggest that general individual merit should be rewarded by salary increases, and that successful research work should be rewarded by a grant to be divided amongst all members of the research staff whether they have participated in the successful research or not."

Finally the writer insists that it is untrue to say that "the ultimate aim of industrial research is mainly financial profit." "The main object of industrial research is to build up a strong and progressive industry."

These views on prizes and bonuses were endorsed at length by several of the members present.

The rights of workers in regard to the patenting of their ideas were also discussed.

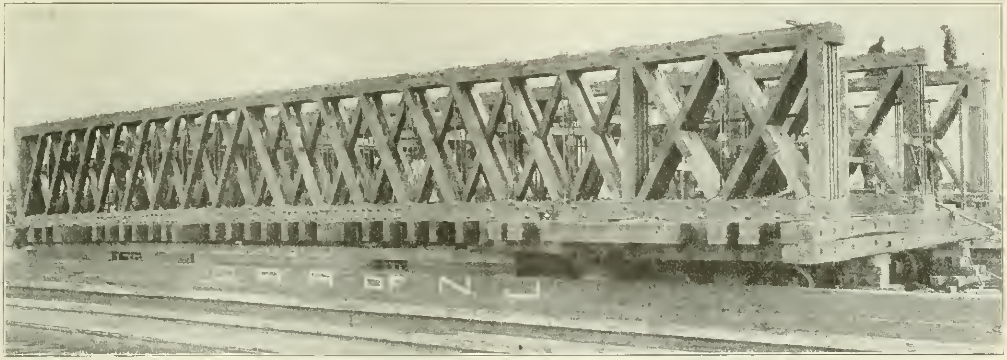
Financing the Work.—The chairman called upon Sir W. Iones (British Refractories) to introduce the fourth subject, "Subscription to Research Associations." Sir William pointed out that the success attending the formation of associations depended mainly on securing sufficient subscriptions from the industry immediately interested. From the experience he had found that the recommendations of the department were open to grave objections. Seven schemes, or tests, had been suggested as a basis for determining the amount of subscription. These included (1) a levy on the total capital; (2) on the average annual profits; (3) on the annual wage bill; (4) on the number of employes; (5) on the volume of the output; (6) on the value of output; and (7) on the amount of plant. Obvious objections could be raised to each of these, but every one involved the disclosure of facts appertaining to the business of individual firms. In face of the general opposition encountered in his particular association the consent of the department was solicited for permission to substitute a voluntary basis for a percentage levy. By approving a voluntary basis it would be possible, and legitimate, not only to approach the manufacturers who were interested in refractories, but also the consumers and all who would derive advantages from the establishment and work of the Research Association contemplated.

Framing a Howe Truss Before Treatment

In these days of steel trusses, examples of wooden Howe trusses are not so common but what a picture and incidentally an unusual method of construction may be of interest. The following is abstracted from an article in a recent issue of the Railway Maintenance Engineer.

This Howe truss is a transfer bridge of the Central Railroad of New Jersey, replacing an old one which had been in continuous service for 13 years at the Bronx terminal in New York City.

The erection of the bridge differed from the customary methods employed in that all the material entering into its construction was shipped direct to the creosoting plant at Port Reading, N. J., where it was assembled into the span. The members composing the bridge were run through the mill at the plant, where, in the majority of instances, they were sized by machinery, and where "gaining" was found necessary, the work was done on a tie-gaining machine. This practically eliminated hand labor and produced a uniform quality of work with a minimum possibility of error. As soon as this work was finished the different members were taken to an open area in the rear of the mill upon which a runway had been constructed previously to facilitate the erection. In assembling the bridge the heavier members were handled by locomotive cranes operating on tracks laid on each side of the runway.



Howe Truss Transfer Bridge of Central Railroad of New Jersey

After the entire structure had been completely assembled and all connections made, the operation was reversed and the span was dismantled piece by piece. Each member was marked carefully for identification and then loaded on tram cars for conveying to the creosoting cylinders, where it received the full cell treatment, having been thoroughly air-seasoned for one year previous to framing. About 8.5 lb. of creosote oil was absorbed per cubic foot of timber.

The work of reassembling was carried on without any serious difficulties. The bridge itself was erected on an old car float about 235 ft. long and 36 ft. wide, drawing about 4 ft. 6 in. of water when light, the float having been moored in a slip between two piers upon which the tram cars carrying the creosoted timbers were run. The actual work of reassembling was similar to that in the original construction, the main difference being that the entire structure was supported, in this case, on six car trucks of 50 tons capacity, each free to run on rails laid on the deck of the car float.

The transfer of old bridge to scows and new bridge from now to its final place and replacement of pontoon, were accomplished by the help of the tide and a derrick with a 50-ft. boom and a lifting capacity of 300 tons, endwise motion being accomplished by the railway trucks under the trusses.

By framing the timber previous to treatment in this manner, it was not necessary to cut into the treated wood, less oil was required and it also cost less to erect, the plant being adjacent to the mill.

Recipe For a City Manager Report

"To make this condiment, the poet begs,
The pounded yellow of two hard boiled eggs."

This is the way Sidney Smith, the famous English humorist starts out a recipe for a salad dressing. Much the same method is used by Harrison G. Otis, Secretary of the City Manager's Association, in making his "recipe" for the preparation of the annual report of a city manager. Mr. Otis suggestions, which are reprinted below from the American City, while intended mainly for city managers, contain "food" for thought for other public officials.

The preparation of an annual report gives to the city manager his one big opportunity to play host to his taxpayers. The fact that the charter usually requires such a report and that the city foots the bill simply increases the obligation resting upon the manager. The report should be a real feast —a Thanksgiving dinner, if you will—so full of fresh, wholesome ideas and food for thought that strangers will devour it from cover to cover.

The citizens will prize more highly the annual report if they have been frequently called upon to help produce the achievements therein chronicled.

A real feast must be carefully planned long in advance. So, too, the annual report. Each week should yield some definite contribution of increased or added service. The field of community welfare should be cultivated to produce a rotation of crops. These crops may be gathered by securing monthly reports from department heads. To each such report should be added suggestions whereby the department's efficiency may be increased. Thus the next crop is planted.

A camera is a handy harvesting tool for gathering "before-and-afters."

As the end of the year draws near, assemble the stores of facts and select the finest specimens of accomplishment. Sort well and plan the meal.

Warnings. (1) Many a good manager is a poor publicity man; better call in the local newspaper writer and make him your chef rather than spoil an excellent meal by poor cooking. (2) "Too many cooks spoil the broth"; your department heads may not have been selected for their literary ability.

Having picked out the best stories, boil them down, after carefully removing the "I's." Season with comparisons. Unrelated facts are often insipid and hard to digest. These comparisons may be in figures, lines, circles, sketches or photographs. Apply them with judgment and remove any trace of bitterness. Use only the quantity needed to bring out the true value of the accomplishments. Stir in a bit of human interest to keep the pot from boiling dry.

Now prepare the financial statements. If these come to you already cooked from the auditor's delicatessen shop, be sure to inspect them carefully. Finances are a necessary but dangerous part of a report and of little value without proper comparisons. Most tables of statistics will stand condensing. Long inventories of bolts and nuts contain little nourishment.

In assembling the courses, three things must be borne in mind: (1) It is a report to the people and worthless unless read, hence it must be readable. (2) It is for the people, hence copies must be delivered to all the taxpayers, or at least to all the holders of realty. (3) It is to be paid for by the people hence don't be extravagant by insisting upon embossed covers and thick volumes.

Now set your table. Reports must be attractively set up. Your public is not so hungry for municipal information that it will dig ravenously into cold hash served in uninviting packages over the clerk's counter. Select good paper, good type, good illustrations. Arrange the courses in logical sequence. You are selling good government. Your report should qualify as a "best seller" except that it must be quite free from "fiction."

Assuming that the stories of achievement are ready to be taken up, prepare them for the report by cutting into short paragraphs set off by spicy subheads in bold-faced type. Each heading should state an interesting fact and not simply label a part of an exhibit.

From these headings select the most toothsome bits as the ingredients of an "appetizer." This may appear as a part of the manager's letter of transmittal or serve as a "foreword" to the report.

If properly prepared and served, the report will find a most enthusiastic welcome and Mr. Taxpayer will smack his lips and pass up his plate for more good government. Perhaps he will even pay his tax bill with pleasure.

For dessert, set forth plans for proposed service and improvements for the coming year, not in full detail but in light outline, so as to leave your guests in a mood of good fellowship and anticipation.

Don't be alarmed at the occasional groan of the chronic curbstone dyspeptic. It is reward enough to see the citizens as a whole smoking the pipe of political peace and planning for another year of united community service.

What Kind of An Engineer Are You?

Editorial in Chemical and Metallurgical Engineering.

Four kinds of technical engineers are to be reported by the census enumerators who are now taking the fourteenth decennial national inventory. Limitation to four varieties is due to an undersupply of cogs in the great census-counting machine now operating at Washington. Civil, mechanical, electrical and mining engineers are to be the proud possessors of these four cogs. All other practitioners of engineering will be forced to trace back their relationship and claim the one of these four titles that appears to be most becoming to them.

Looking at the matter from the basis of alphabetical initials of engineering titles, there seems to be one too many cogs supplied. For only three combinations of C, M and E are required to designate those chosen, as well as the left out, chemical, metallurgical, marine, military, efficiency, as well as that large cosmopolitan class called etcetera engineers. However, not wishing to detract from the seriousness of the subject, it may be asserted that engineers as a whole are not inclined to be overly particular about their titles. The reason for this it that, as they become more proficient, they widen their scope to cover an increased amount of engineering activities in other fields.

It is probable that the great majority of the readers of this journal will choose to be counted with the mechanical engineers. Any one of the other three of the four chosen could do the same without stretching their qualifications very far. The civil engineer deals mainly with the static mechanics of bridges, highways, railroads and pipe lines. The electrical engineer has mastered the mechanics of electrical phenomena. The mining engineer has been schooled so that he is able to direct the activities of machines and miners in the bringing forth of mineral and ore. No outsider should register among these specialized groups unless he is very closely associated with one of them and more than slightly familiar with its work.

As the census years go by, it is to be hoped that other cogs will spring forth and that the chemical and metallurgical engineers will be separated from this broad classification, which from its very nature is capable of subdivision without end and must always provide for the etcetera engineers.

Civil Engineers Aid in Keeping Transportation Open During Strike.—The Michigan Central Railroad Section of the American Association of Engineers recently adopted a resolution offering the services of each of its members to the management of that railroad during the recent railroad strike. The Pennsylvania Railroad Section postponed its annual convention to be held at Pittsburgh on April 27 in order that its members might render such extra service that they might be called upon to perform on account of the strike. Railroad members of the association all over the United States have been engaged in all sorts of extra duty, such as firing engines, throwing switches, running engines, etc. One switching crew on the Burlington made up entirely of civil engineers, performed work consistently in from 50 to 60 per cent less time than was occupied by the regular crew in performing the same duties.

Personals

Arthur Hopkins has resigned as city engineer of Clinton, Ia.

Clarence L. Melcher has been reappointed county superintendent of highways for Bureau County, Illinois.

F. C. Richards has accepted a position as superintendent for the C. A. Carson Construction Co. at Cleveland.

James E. Blackwell, an architect of Seattle, Wash., has been appointed superintendent of buildings for that city.

Maj. Daniel J. McCoy, head of the street repair department of San Francisco, has been appointed commissioner of the Board of Public Works of that city.

F. O. Sylliaasen has resigned as structural engineer and plan examiner for the city building department of Seattle, Wash., to accept a position with a large contracting firm at Memphis, Tenn.

Ritchie Lawrie, Jr., director of the Pennsylvania State Chamber of Commerce Housing Bureau, and Clayton J. Lappley, architect, have formed the partnership of Lawrie & Lappley, with offices at 206 Market street, Harrisburg, Pa.

J. H. Bower has resigned as general superintendent of the engineering branch of the Canadian Department of Soldiers' Civil Re-establishment, and will re-enter a large engineering and contracting company in Montreal. He also will specialize as a hospital consultant.

Samuel P. Hall, formerly of the construction division of the U. S. Quartermaster Corps, and Col. Harold M. Bush, recently of the field artillery, and mechanical engineer, have entered into a partnership under the firm name of Hall & Bush and will engage in a general architectural and engineering practice with offices at 16 South Third street, Columbus, O.

J. D. York, John C. Regan and **E. J. Burke** have entered in a partnership under the firm name of York, Regan & Burke, with offices at 1323 North Clark street, Chicago, and will engage in an architectural and engineering business, specializing in concrete engineering, theater construction, buildings, bridges, concrete steel structures, industrial plants, churches and civic improvements.

A. H. Fuller, for 18 years dean of engineering at the University of Washington and at present director of engineering at Lafayette College, has been appointed head of the civil engineering department at Iowa State College and will take up his duties there July 1. He will also act as consulting engineer of the Iowa Highway Commission. Professor Fuller was associated with Gustav Lindenthal on the design of the Hell Gate Arch over East River in New York. He has just been engaged with C. E. Fowler in some important investigations of the Niagara River R. R. arch bridge, the first great railway arch in this country, which Mr. Fowler and Professor Fuller have now strengthened at very moderate cost, as a result of their scientific tests, to carry safely 50 per cent greater live loads than the original design contemplated. He was a member of the commission which revised the building code of the City of Seattle and has been president of the Pacific Northwest Society of Engineers. Professor Fuller was graduated from Lafayette College in 1897 and received his master's degree from Cornell University in 1898. Later he received his Master of Science degree from Lafayette College. He is a member of the American Society of Civil Engineers, Pacific Northwest Society of Engineers, American Society for Testing Materials and Society for Promotion of Engineering Education.

Industrial Notes

William N. Keiser has been appointed manager of the general construction equipment department of the Lakewood Engineering Co. Cleveland. Mr. Keiser formerly was sales manager of The Parsons Co., Newton, Ia. Later he was with the Hydraulic Steelcraft Co., Cleveland.

N. C. Hall has joined the sales organization of The Holt Manufacturing Co., Inc., Peoria, Ill. He will assist D. C. Reeves, the domestic sales manager, in building up a thorough system of distribution for the "Caterpillar" Tractor. Mr. Hall has been prominently identified with the automotive and tractor profession and from 1914 to 1916 was a member of the firm of Hall Bros. & Reeves. Kansas City. In 1916 he became associated with the J. I. Case Plow Works and distributed the Wallace tractor in Kansas City.

The second annual meeting of the Industrial Car Manufacturers' Institute was held in Pittsburgh on April 20. The following board of directors was elected: Lion Gardiner, vice-president, The Lakewood Engineering Co., chairman; N. A. Doyle, vice-president American Car & Foundry Co.; W. E. Farrell, president, Easton Car & Construction Co.; J. M. Hansen, president, Standard Steel Car Co.; J. R. Kilbourne, vice-president and general manager, The Kilbourne & Jacobs Mfg. Co.; R. J. Magor, president, Magor Car Corp.; J. C. Shirer, president, The Star Manufacturing Co. Col. James Milliken was re-elected president of the Institute and H. M. Wey secretary.

H. E. Bilger, consulting engineer, Monmouth Stone Co., Monmouth, Ill., has resigned to become general manager of the Highway Culvert Form Co., Peoria, Ill. The new company has taken over the business of another company of the same name at Ottawa. Ill., which has for the last 10 years been manufacturing collapsible one-man forms of the arch type. This arch form is Mr. Bilger's invention, and in addition he has just invented a similar form of the flat-top type, which with the arch will be manufactured and distributed out of Peoria. For twelve years Mr. Bilger was a civil service employe of the Illinois State Highway Department in the capacities of assistant bridge engineer and road engineer, besides having served as senior highway engineer with the U. S. Office of Public Roads.

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Road and Street Monthly Issue

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Roads and Streets—1st Wednesday
(a) Roads
(b) Streets
(c) Street Cleaning
(d) Municipal Miscellanies
(e) Management and Office System

Waterworks and Hydraulics—2nd Wednesday
(a) Waterworks
(b) Sewers and Sanitation
(c) Irrigation and Drainage
(d) Power and Pumping
(e) Management and Office System

Railways and Excavation—3rd Wednesday
(a) Excavation
(b) Management and Office System
(c) Quarries and Pits
(d) Steam Railways, Construction and Maintenance
(e) Electric Railway Construction and Maintenance

Buildings and Structures—4th Wednesday
(a) Buildings
(b) Bridges
(c) Harbor Structures
(d) Miscellaneous Structures
(e) Properties of Materials
(f) Management and Office System

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The Effect of Exports Upon Average Commodity Prices

By HALBERT P. GILLETTE, Editor.

In the April 7 issue of Engineering and Contracting there appeared the following statement in my article on "A Quantitative Analysis of All Factors that Affect Average Prices":

> Scarcity of commodities in Europe affects average prices in America only in one of two ways:
>
> (1) By the shipment of gold to America, and
>
> (2) By increasing the rate of money turnover.

Further consideration of the matter leads me to add a third factor, namely. (3) a reduction in the normal quantity of commodities available for American consumption. This reduction has the same effect upon average prices as would occur were there an actual decrease in our per capita productive efficiency.

There have been only three years since 1875 that our imports have exceeded our exports. During the fifteen years prior to the world war, the excess of merchandise exports over imports was as follows, by five-year periods:

	Millions
June 30, 1899, to June 30, 1904	$2,552
June 30, 1904, to June 30, 1909	2,381
June 30, 1909, to June 39. 1914	2,385
Total, millions of dollars	$7,318

During the same 15-year period, we imported 52 million dollars of gold in excess of our gold exports. Our merchandise "balance of trade," which averaged 470 million dollars a year for 15 years prior to the war, was paid for mainly in three ways:

(1) By interest and dividends on American securities owned by foreigners;
(2) By money spent abroad by American tourists, and
(3) By money earned by foreigners resident in America, but sent abroad and used to buy American commodities.

Taking the five years preceding the war, we see that our our merchandise exports exceeded our imports by an average of 467 million dollars annually. In Table XVI of my article in the April 7th issue, it will be seen that our average annual production of wholesale commodities during the same five-year period was 18,400 million dollars. Hence our annual excess of exports over imports averaged about 2.5 per cent of the total commodities that we produced. In my price formula this 2.5 per cent does not appear as a corrective factor, but it is automatically taken care of in the constant K. which equals 0.5

Table I. Column "A," gives the "balance of trade" for each of the last five calendar years in millions of dollars. To reduce these dollars to the same purchasing power as existed in 1913, the total for each year (as given in Column "A") is divided by the average commodity index price for the corresponding year (as given in Column "B")

E. and C. Now $4 a Year

The greatly increased cost of all items entering into the production of Engineering and Contracting makes it necessary for us to increase the subscription price to $4 a year. The specialized monthly issues can be subscribed for, as heretofore, at $1 per year. We have realized for some time that we would have to increase our subscription price but have delayed taking the step in the hope that changing conditions would make such action unnecessary. We are now obliged, however, in view of the increased scale of costs in all branches of our business to definitely announce the advance in subscription price to $4.

TABLE I.

Calendar year.	A. Excess of exports over imports.	B. Index price.	C. Column "A" ÷ "Column "B".
1915	$ 1.776	100	$1,775
1916	3.091	123	2,513
1917	3.282	175	1,818
1918	3,118	196	1,585
1919	4,017	214	1,872
Total	$15.284		$9,764

and the quotient (as given in Column "C") is the number of dollars of "balance of trade" expressed in terms of the buying power of a dollar in 1913. This "equated value" of the excess of exports over imports is 9,764 million dollars for this five-year period, or about 1,953 million dollars per annum, as compared with 467 million dollars per annum prior to the war.

Table XVI of my article in the April 7 issue shows that the annual production of wholesale commodities averaged 1,975 for the years 1914 to 1918. Hence it follows that the excess of exports over imports during the years 1914 to 1919 averaged about 10 per cent of the total commodities produced during those years, as compared with 2.5 per cent during the prewar years; thus producing an abnormal deficiency of commodities for home consumption amounting to 7.5 per cent of the total annual production.

So far as its effect upon the American average wholesale commodity prices is concerned, this abnormal balance of trade of 7.5 per cent has acted precisely as if there had been a 7.5 per cent decrease in productivity. Hence the percapita productivity coefficient (the E in my price formula) must be decreased 7.5 per cent for each of the five calendar years, 1915 to 1919, inclusive. The effect of this is to increase my calculated index prices for those years given in Table I and Figure 1 of my April 7 article) by 8 per cent. Making this change, my calculated index prices are as follows:

	Index prices.	
	Calculated.	Actual.
1915	100	100
1916	128	123
1917	163	175
1918	190	196
1919	207	214

When the United States Census statistics of population for 1919 are published, it will be found, I think, that the actual population is about 3 per cent less than the estimated population. The Census Bureau has already published the population of 449 cities, totaling about 10 million people; and the results show that, whereas those cities increased 28.4 per cent in population during the decade ending in 1909, the increase was only 21.9 per cent during the decade ending in 1919. Should the actual population of America in 1919 be 3 per cent below the Census Bureau estimate which I used in my price formula, the effect will be to increase my calculated index price for 1919 by 3 per cent, thus making is agree almost precisely with the actual index price of 214.5 given by the United States Bureau of Labor.

Of course, absolute agreement between actual and calculated index prices is not to be expected, for none of the data are precise. For example, as a result of a special investigation by the Director of the Mint, it was found that the estimate of gold coin in circulation was 135 millions of dollars too great in 1906, and accordingly the estimate for July 1, 1907, was reduced 135 millions. This 135 millions is about 5 per cent of the total currency in circulation at that time. Had I corrected for this overestimate of currency circulation, it would have lowered my calculated index price for the year 1906 by 5 per cent, and by a somewhat similar percentage for the immediately previous years. I made no such correction, however, because I had no means of ascertaining for how many years the overestimate of 135 millions had existed. Reference to Figure 1 and Table I of my article of April 7 will show that such a correction would bring my calculated index prices even closer to the actual index prices than they were.

In this connection it should be pointed out that a change in the quantity of currency is not necessarily followed by an instantaneous change in commodity prices. It usually requires two or more months for the effect of a change in currency to manifest itself in a corresponding change in prices.

While precise agreement between actual and calculated index prices is not to be had for any single year, there should be substantial agreement when the averages of two or three years are taken. By this test, it will be seen that, for the last 10 years (the period during which all the data for the five factors in my price formula are available), there is such close coincidence between the actual and the calculated index prices as to be convincing proof of the substantial accuracy of the formula.

Method of Calculating Vertical Curves

To the Editor: Referring to the recent discussion in your columns as to methods of calculating vertical curves, I have to say that in my practice I find it easier to fit the contour of the ground by selecting some definite length for the tangent distances. It is then easy knowing the elevation of the grade intersection and the percentages of grade on either side, to determine the elevations of the points of curvature. The mean of these two latter elevations gives the elevation of the center point of the long chord, and the mean of this with the elevation of the intersection of grades (assuming a parabolic curve) gives the elevation of the apex or center point of the curve. If this is found to be either too high or too low to fit the ground, it is an easy matter to adjust by assuming a slightly greater or a slightly less length for the tangents.

In staking out intermediate points on the curve, I find the appended table to be convenient. This table gives in Column 2 the elevations for each foot for any point on a parabolic curve 100 ft. long with approaching grades on either side of 4 per cent, and elevation of the P. V. C. of zero; or, in other words, with an external equalling 1 ft. Column 3 gives the distances from the grade line produced to the corresponding point on the curve. With an external other than 1 ft., the proper distances can readily be found by simple proportion, and for other lengths of curve the proper point for entering the table can also be easily determined by simple proportion. Knowing, then, the elevation of the given station along the long chord, the proper elevation for the point on the curve can be obtained by addition of the quantity deduced from Column 2 if the curve be convex upward, or by subtraction if it be convex downward. Knowing the elevation for the given station along the straight grade produced, the proper elevation for the point on the curve can be obtained from the quantity reduced from Column 3 in a similar manner, reversing the sign of the operation.

PROPER ELEVATIONS, ETC., FOR A VERTICAL CURVE 100 FT. LONG JOINING TWO TANGENTS OF 4 PER CENT EACH, THE CURVE BEING CONVEX UPWARD, AND THE LONG CHORD LEVEL AT ELEVATION ZERO.

1.	2.	3.	1.	2.	3.
1	0.0396	0.0001	26	0.7696	0.2704
2	0.0784	0.0016	27	0.7884	0.2916
3	0.1164	0.0036	28	0.8064	0.3136
4	0.1536	0.0064	29	0.8236	0.3364
5	0.1900	0.0100	30	0.8400	0.3600
6	0.2256	0.0144	31	0.8556	0.3844
7	0.2604	0.0196	32	0.8704	0.4096
8	0.2944	0.0256	33	0.8844	0.4356
9	0.3276	0.0324	34	0.8976	0.4624
10	0.3600	0.0400	35	0.9100	0.4900
11	0.3916	0.0484	36	0.9216	0.5184
12	0.4224	0.0576	37	0.9324	0.5476
13	0.4524	0.0676	38	0.9424	0.5776
14	0.4816	0.0784	39	0.9516	0.6084
15	0.5100	0.0900	40	0.9600	0.6400
16	0.5376	0.1024	41	0.9676	0.7624
17	0.5644	0.1156	42	0.9744	0.7056
18	0.5904	0.1296	43	0.9804	0.7396
19	0.6156	0.1444	44	0.9856	0.7744
20	0.6400	0.1600	45	0.9900	0.8100
21	0.6636	0.1764	46	0.9936	0.8464
22	0.6864	0.1936	47	0.9964	0.8836
23	0.7084	0.2116	48	0.9984	0.9216
24	0.7296	0.2304	49	0.9996	0.9604
25	0.7500	0.2500	50	1.0000	1.0000

Notes:

Column 1 gives the stationing forward from P. V. C. and backwards from P. V. T.

Column 2 gives the elevation of the vertical curve or the amount to be added algebraically to the elevation of the long chord for the same stationing.

Column 3 gives the distance between the tangent produced and the curve, or the amount to be subtracted algebraically from the elevation of the tangent produced for the same stationing.

All calculations based on a parabolic curve.

For instance, take a grade of plus 1.2 per cent meeting a grade of plus 3.6 per cent at Station 46 plus 75, the elevation of the intersection being at 798.66. Suppose that a chord length of 150 ft. seems best to fit the contour of the ground. P. V. C. is found to be at Station 46 and at elevation 797.76, while P. V. T. is found to be at Station 47 plus 50 and at elevation 801.36. The mean of these elevations is

799.56, the mean of the latter with the elevation of the summit is 799.11, the elevation of the apex or center point of the curve, the external is 0.45, the curve being convex downwards, and we will say that this seems to fit the ground very well.

To find the proper elevation for Station 47, which happens to be two-thirds of the way, measured backwards, from the P. V. T., we enter the table at line 33 and find in Column 3 the quantity 0.4356, which multiplied by the external (already found to be 0.45) gives 0.196 as the distance up from the tangent produced to the vertical curve. The tangent produced is here 1.8 below the grade at P. V. T., and is easily found to be at elevation 799.56. We therefore find the elevation on the curve for Station 47 to be 799.76.

I find that the use of this table is really simpler than it appears to be at first sight.

Cleveland, Tenn. S. D. NEWTON.

Bidding Prices on Iowa Road Work

Low bids at road lettings in Iowa during February and March ranged from $3.59 to $4.85 per square yard on concrete pavement, and from $5.11 to $6 per square yard on brick pavement and from 54 ct. to $1.45 per cubic yard on grading. During these two months contracts were let for paving 106.2 miles of highway. Of this total 84.5 miles are concrete, let at $3.59 to $4.37 per square yard, and 21.7 miles are brick, let at $5.43 to $5.93 per square yard. The total grading and excavation contracted amounted to 682.427 cu. yd., which was let at prices varying from 56 ct. to $1.48 per cubic yard. In addition 11 miles of graveling was let at 90 ct. per yard. The 1920 program calls for about 300 miles of highwty. The folowing table from the February and March Service Bulletin of the Iowa Highway Commission shows the low bids at lettings held in the various counties:

County.	Date.	Concrete. Miles.	Concrete. Price.	Brick. Miles.	Brick. Price.	Grading. Cu. yd.	Grading. Price.
Greene		**6.5**	**$3.59**	....	....	**17,442**	**$1.00**
Black Hawk	Feb. 10	17.17	4.59	10	$6.00	**181,475**	1.00
Buchanan	Feb. 11	8	4.45	8	5.95	20,279	1.00
Appanoose	Feb. 12	....	....	....	....	**101,392**	**.64**
Polk	Feb. 16	**2.8**	**4.37**	2.8	5.49	**4,315**	**1.44**
		6.57	**4.12**	6.57	5.11	**23,486**	**1.48**
						17,500	**.54**
Winnebago	Feb. 20	....	....	....	*	30,042	.74
Humboldt	Mar. 2	1.85	4.21	....	*	23,208	.98
Palo Alto	Mar. 3	11.05	4.15	....	....	**10,330**	**1.10**
Black Hawk (reletting)	Mar. 4	17.17	4.10	....	....	49,146	1.09
Wapello	Mar. 6	....	....	....	....	135,924	.75
Linn	Mar. 11	**6.5**	**4.14**	....	....	**7.800**	**1.20**
Wright	Mar. 15	....	....	....	*	**120,532**	**.69**
Pocahontas	Mar. 16	....	....	....	*	**139,067**	**.70**
Marshall	Mar. 16	....	....	....	*	**75,395**	**.68**
Cerro Gordo	Mar. 17	**5.14**	**3.74**	....	....	**21,060**	**1.31**
		15.44	**3.59**	....	....	**31,567**	**1.00**
		7.54	**3.94**	....	....	**20,670**	**1.10**
Floyd	Mar. 18	**6.93**	....	....	....	27,941	....
		4.61	**4.09**	....	....	**20,125**	....
Pottawattamie	Mar. 18	....	....	....	....	55,250	.645
Greene	Mar. 18	....	....	....	*	**35,736**	**.68**
O'Brien	Mar. 19	**8**	**4.32**	....	....	**24,663**	....
		8	**4.32**	....	....	**24,663**	....
		5.5	**3.94**	....	....	**15,384**	....
Scott	Mar. 25	4.46	4.34	**4.46**	**5.48**	......	....
		5.38	4.17	**5.38**	**5.58**	......	....
		6.44	4.85	**6.44**	**5.93**	......	....
		5.42	3.99	**5.42**	**5.43**	......	....

Summary shows low bid at letting; plain type indicates no award made at time of summary; black face indicates contract awarded by board of supervisors; star indicates contract on county road system.

How Ontario Towns Finance Street Paving.—The method of financing street paving in towns and villages of the Province of Ontario varies all the way from the whole cost being borne by the municipality to the municipality paying but 2 per cent. Paving may be undertaken as a local improvement, either on petition, on the initiative or on the forced local improvement as provided in Section 9 of the Local Improvement Act; or the council may submit a by-law to the people to raise funds for paying for all the pavement or part thereof. A canvass recently made of 26 Ontario towns showed that in 66 per cent, the abutting property pays all.; in 8 per cent, the abutting property pays 50 per cent; in 24 per cent, the abutting property pays more than 50 per cent and less than 60 per cent; in 2 per cent, the municipality pays all. These percentages, stated E. A. James in a paper presented at the March Conference of County Road Superintendents and Engineers of Ontario, include the street intersections and flankages which the Act requires the municipality to pay.

Status of Federal Aid Road Fund

Over $34,850,000 of Federal Aid funds from the apportionment for the fiscal year 1920 were available on March 31. The status of these funds on that date, based on projects approved, as reported by District Engineers, was as follows:

State.	Balance available from apportionment for fiscal year 1920.	Balance available from apportionment for fiscal year 1921.†	Total apportionment still available.
Alabama	*$1,995,501	$2,104,883	$4,172,989
Arizona	810,213	1,373,644	2,183,858
Arkansas	1,156,091	1,685,178	2,811,269
California	322,593	3,054,675	3,377,269
Colorado	1,596,537	1,755,759	3,352,296
Connecticut	137,547	613,349	750,896
Delaware	17,290	162,674	179,965
Florida	602,816	1,147,447	1,750,264
Georgia	....	2,564,693	2,564,693
Idaho	....	1,027,253	1,027,253
Illinois	....	2,505,801	2,505,801
Indiana	....	16,602	16,602
Iowa	....	279,240	279,240
Kansas	....	1,957,843	1,957,843
Kentucky	‡1,856,043	1,951,755	4,061,753
Louisiana	47,966	1,362,231	1,410,197
Maine	....	750,671	750,671
Maryland	....	465,990	465,990
Massachusetts	925,017	1,472,788	2,397,806
Michigan	930,752	2,891,667	3,822,420
Minnesota	....	1,708,409	1,708,409
Mississippi	1,307,227	1,807,557	3,114,784
Missouri	796,972	3,387,899	4,184,871
Montana	1,558,098	2,006,990	3,565,088
Nebraska	....	1,085,814	1,085,814
Nevada	1,152,498	1,276,344	2,428,842
New Hampshire	19,054	414,838	433,893
New Jersey	....	272,119	272,119
New Mexico	721,462	1,598,467	2,319,930
New York	4,485,582	4,971,895	9,457,475
North Carolina	....	289,124	289,124
North Dakota	609,355	1,536,227	2,145,583
Ohio	731,797	3,706,246	4,438,044
Oklahoma	1,058,599	2,302,478	3,361,077
Oregon	67,027	1,576,152	1,643,179
Pennsylvania	....	4,467,785	4,467,785
Rhode Island	133,074	233,256	366,331
South Carolina	844,009	1,436,019	2,280,028
South Dakota	362,200	1,615,779	1,977,980
Tennessee	2,069,075	2,261,913	4,330,989
Texas	4,844,640	5,861,598	10,706,238
Utah	....	320,530	320,530
Vermont	359,304	450,077	809,381
Virginia	1,146,248	1,977,673	3,123,922
Washington	....	909,812	909,812
West Virginia	....	856,999	856,999
Wisconsin	2,341,489	2,544,945	4,886,434
Wyoming	674,153	1,233,715	1,907,869

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*Includes $72,664 from 1917-18-19 apportionment. †Funds cannot be used prior to June 30, 1920. ‡Includes $253,954 from 1917-18-19 apportionment.

Cost of Road Grading with Tractors.—Tractors have given good service in road grading in Brant county, Ontario. Practically all heavy work of this kind in 1918 was done by this method. The following costs on this work are given by Widmund Huber, Assistant Engineer, Ontario Department of Public Highways, in the annual report of the department for 1918:

AVERAGE DAILY OPERATING COSTS OF 10-20 HP. TRACTOR.

Fuel—15 gals. kerosene at 18 ct.	$ 2.70
Oil—½ gal. at 70 ct.	.35
Operator on tractor	4.00
Operator on grader	4.00
Repairs, etc.	.50
Total	$11.55

A day's work with one 8-16 hp. tractor was from ¼ to ⅓ mile, while with the 10-20 hp. machine from ¼ to ½ mile was done, depending on the season, previous condition of the road, character of soil, amount of work required, etc.

Experience with even the smaller sizes of tractors, states the report, has demonstrated the superiority of this method of conducting grading operations over the employment of teams, both as regards cost of operation and work accomplished.

Average Expenditures on Iowa Roads.—The average expenditure on county and primary roads in Iowa has increased from $191 per mile in 1915 to $312 per mile in 1919, according to the February-March Service Bulletin of the Iowa Highway Commission. The total road mileage of the state is 104,082, of which 6,421 miles are classed as primary roads, 10,443 miles as county roads, and 87,218 as townships. The average expenditures per mile on these roads for a 5-year period have been as follows:

	1915.	1916.	1917.	1918.	1919.
County and primary roads	$191	$204	$223	$228	$312
Township roads	40	44	46	45	46
Bridges average, all roads	66	69	71	67	66
Average total expense per mile roads and bridges (104.082 miles)	130	138	146	135	155

Assisting the Inspector on Public Work

By H. J. FIXMER,
Paving Engineer, Chicago.

The position of inspector on public work is a "job" requiring certain knowledge, tact and authority. The duty of the inspector is, fundamentally, to see that the work is carried out according to the specifications, instructions from his superiors, and in a way that experience has taught him is right and successful. There are two parties to the contract: the public and the contractor. While the inspector represents the public it should be impressed upon him that he is to cooperate with the contractor in getting the desired results and not antagonize him. That authority is best and most succesful which expresses itself in constructive helpful criticism, rather than the destructive, arrogant attitude so common in the ignorant or inexperienced.

Many inspectors acquire a wrong attitude from incomplete instruction, restricted authority, lack of interest and timid personality. The inspector must be firm. To be firm he must know where he stands. If he has knowledge, tact, and the support of his superiors it will be easy for him to secure the respect of the contractor and thus "get results" quietly and pleasurably. It is therefore the first duty of the inspector to know the work in hand.

Most public work consists of units of construction that have been or can be standardized. Probably the greatest friction develops when a standard is changed or modified and the inspector is unable to "check" results. It is the duty of the head office to supply the inspector with complete data to enable him to know how to proceed. It is then the duty of the inspector to inform the contractor and assist him in adjusting matters. Some organizations keep the necessary data secret with the idea of applying them to the work after the work is completed for the purpose of "showing up" the inspector or condemning the contractor. This is unfair and is demoralizing all around. The inspector should know at the time the work is being done how to check the quantities or determine their suitability. After the work is done is certainly too late.

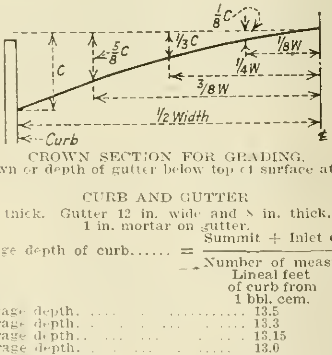
The inspector merits the confidence of the authorities. To this end his superiors should take an interest in his problems and relieve him of all anxiety, doubt or unmerited blame. It is wise to furnish the inspector with complete data on his duties, authority and the work in hand. This increases his confidence, excites his interests, makes him firm but honest in action, educates him, and increases his assumption of responsibility. Books of instruction are excellent, but these should be supplemented by charts, data sheets or other forms of up-to-the-minute information.

A typical data sheet, particularly applicable to paving work in the city of Chicago, is shown to indicate one method of presenting data of direct use to the inspector. From this sheet he is able to lay out or check the crown of the subgrade or finished pavement. The amount of cement required in walks, curbs, curb and gutter and to support stone curbing is readily determined. The amount of cement used in concrete pavements, bases or walls can be safely estimated from one of the tables. The amount of brick or asphalt required is easily checked; also the quantities necessary for cushions and fillers.

The inspector, as a rule, directly represents the engineer and must approach the execution of the work in sympathy with and from the standpoint of the engineer. Accuracy is the first requirement. The inspector should check all plans in advance of the work and consult with the engineer where any doubts or misunderstandings arise. It will not do to excuse a discoverable error by saying the plans called for it. Simple errors can generally be corrected by an intelligent man without the assistance of the engineer, but the engineer should be quietly apprised of them. This adds to their mutual confidence. The engineer, unless young and inexperienced, welcomes constructive suggestions.

The inspector, being continuously on the job, becomes well known to the public as well as the contractor and his men. The public's judgment (?) not only of the work being done, but of the whole organization is very often based on the impression made by the inspector. In his relations with the public, his superiors, and the contractor and his men is where tact, knowledge, experience, personality count. Good inspectors are indeed hard to "find"; they must be trained. Because of the broad way an inspector affects public work, his relations with the work, with his superiors, with the contractor and with the public, more attention should be given to the selection and training of the inspector. His position should be respected, made permanent and certainly properly

Chart Illustrating One Method of Presenting Data of Direct Use to the Inspector.



CROWN SECTION FOR GRADING.

C = Crown or depth of gutter below top of surface at center line of street.

CURB AND GUTTER

Curb 7 in. thick. Gutter 12 in. wide and 8 in. thick. 1:2:4 mix. 1 in. mortar on gutter.

$$\text{Average depth of curb} \ldots\ldots = \frac{\text{Summit} + \text{Inlet depths}}{\text{Number of measurements}}$$

	Lineal feet of curb from 1 bbl. cem.	Bbl. cem. for 1 lin. ft.
4 in. average depth	13.5	.0741
4½ in. average depth	13.3	.0752
5 in. average depth	13.15	.0760
5½ in. average depth	13.0	.0770
6 in. average depth	12.75	.0784
6½ in. average depth	12.5	.080
7 in. average depth	12.25	.0815

Vertical concrete curb: 1:2:4 mix; 7 in. x by 9 in. x 24 in.; 1 bbl. cement lays 14 lin. ft.; bbls per lineal foot = .0715.

Stone curb on concrete saddles and backing: Mix = 1:3:6. Where length of saddle is 18 in., requiring 1½ cu. ft. per joint, 1 bbl. cement lays 18 joints.

Where length is 24 in., requiring 2 cu. ft. per joint, 1 bbl. cement lays 13½ joints.

Sidewalk: 5 in. thick, 4¼ in. of 1:2½:5 mix. ¾ in. of 1:1½ mix top. 1 bbl. cement lays 40 sq. ft.

CONCRETE PAVEMENT OR BASE.

Barrels of cement (4 bags) required per 1 sq. yd. of surface. Voids assumed at average of 45%.

Mix.	Bbls. per cu. yd.	Thickness of concrete in inches					
		1.	5.	6	7.	8.	9.
1:1	3.88	.1077	....	....	....	....	....
[illegible]	3.20	.0889	....	....	....	....	....
[illegible]	1.91	.0531	....	....	....	....	....
1:2 :3	1.75	.0484	.242	.291	.338	.387	.435
1:2 :4	1.50	.0417	.208	.250	.292	.334	.375
1:2½:5	1.25	.0347	.174	.208	.243	.278	.312
1:3 :5	1.17	.0325	.162	.195	.227	.260	.292
1:3 :6	1.05	.0291	.143	.172	.206	.232	.260
1:3 :7	0.92	.0255	.127	.153	.178	.204	.230

7 in., 1:2:3=3 sq. yd. per bbl.; 6 in., 1:3:6=6 sq. yd. per bbl.; 6 in., 1:3:7=6½ sq. yd. per bbl.

Note—Observe decimal point. Actual yardage must not be 4% in excess of amount computed from table.

TABLE FOR ALLEY CURBS.

Width of curb, 8 in.

	Depth of curb in ins.	Lineal feet per bbl. cem.	Bbls cem. per lin. ft. cb.
3 in. wood, brick; 1 in. cush., 6 in. conc.	10	48	.0208
3½ in. wood, brick; 1 in. cush., 6 in. conc.	10½	46	.0218
4 in. wood, brick; 1 in. cush., 6 in. conc.	11	44	.0228
4 in. brick, stone; 2 in. cush., 6 in. conc.	12	40	.0250
5 in. stone; 2 in. cush., 6 in. conc.	13	37½	.0266
4 in. brick, wood, stone; 1 in. cush., 8 in. conc	13	37½	.0266

ASPHALT.

	No. of lbs. per sq. yd. = Z.
1 in. binder	93⅓
1½ in. binder	140
1½ in. top	150
2 in. top	200

$$\text{Sq. yds. per load} = \frac{\text{Weight box} \times \text{No. boxes}}{Z}$$

BRICK.

Standard.

Depth.	Number required per. sq. yd.
3 in. laid flat	35
4 in. on edge	45

1 bbl. cement = 4 bags.
1 bag cement = 1 cu. ft.

Cushions: 1 in. sand lays 36 sq. yd. per cubic yard sand; 2 in. sand lays 18 sq. yd. per cubic yard sand; 1 in. mortar (1:4 mix), 1 sq. yd. requires .050 bbl. cement; 1 in. mortar (1:3 mix), 1 sq. yd. requires .065 bbl. cement.

Fillers: Grout (1:1 mix), 4 in. repressed 1 sq. yd., .032 to .037 bbls.; 4 in. wire cut 1 sq. yd., .040 to .045 cement; asphalt for brick = ½ to ¾ gal. per square yard.

remunerated. It is possible to raise the "job" to the dignity of a profession. This merits serious consideration.

Thawing Frozen Grounds With Cold Water

Experiments made at Nome, Alaska, by Mr. John H. Mills, indicate that frozen gravel can be thawed much more readily with cold water than with steam. The tests were made on a formation consisting of tundra, muck, quicksand.

Clay and fine gravel. The results are summarized as follows in an article by Walter S. Weeks in the Mining and Scientific Press:

Super-Heated Steam Thaw.	Saturated-Steam Thaw.	Warm-Water Thaw.	Cold-Water Thaw.
156 hours steaming.	98 hours steaming.	67 hours thawing.	192 hours thawing.
1.755 gal. oil used.	882 gal. oil used.	405 gal. oil used.	20 gal. water per min.
160° C. steam at boiler.	160° C. steam at boiler.	44 ft. depth of ground.	40-ft. pressure.
310° C. steam at points.	120° C. steam at points.	105° F. water at points.	52° F. water entering.
60° C. water at surface.	40° C. water at surface.	70 F. water at surface.	511 cu. yd. thawed.
109 cu. yd. thawed.	83 cu. yd. thawed.	81 cu. yd. thawed.	1.9 ct. cost per yard.
			$5.75 cost of drilling hole to install thaw-pipe.
			$4.20 cost of connecting and disconnecting pipe.
			No charges made for use of water.

Note. Cost of oil 8 ct. per gal. 70 ct. per hour cost of labor when thawing. $11.50 per shift for labor when inserting points.

In the cold water thaw water at a temperature of 52° F. was used; the temperature of the ground was 28° F. As ditch pressure was not available a steam pump with a 2-in. suction and ½-in. discharge was used. This pump delivered 20 gal. per minute at an average pressure equal to a 40-ft. head. The pump was connected to a 2-in. pipe, which was dropped into a 6-in. Keystone drill-hole. No results were apparent for 24 hours, when the "muck" began to slough from the sides of the hole and retarded the circulation of water in the hole. From that time on one could see the progress of thawing. In 36 hours an 8-ft. area was thawed, and upon probing with an iron rod it was found that the walls of the thaw were vertical, not the shape of an inverted cone as in the steam thaws. At the end of the eighth day, it was decided to stop thawing on this hole and start another for a check, owing to the lateness of the season. The water entering the ground had a temperature of 52°; at the end of 24 hours the outgoing water was at 50°; at the end of 48 hours, 48°; at the end of 72 hours, 45°; at the end of 86 hours, 40°; at the end of 192 hours, 36°. To obtain maximum efficiency the amount of water entering the thaw-pipe should be governed by the temperature of the outgoing water. Just enough water should be used to keep the temperature of the outgoing water a little above freezing.

Engineering and Construction Features of Earth Road Work in Nebraska

Information on the engineering work for earth road construction in Nebraska was given by Mr. A. S. Mirick, Chief Construction Engineer, Nebraska Department of Public Works, in a paper presented last March at the Nebraska Road Institute. The notes that follow are abstracted from his paper.

There are about 80,000 miles of earth roads in the state and no matter how great a hard-surface program we launch, this day and generation will pass by with at least 75,000 miles of earth roads still with us.

Some have questioned whether earth road improvement could be called permanent improvement. There are certain features of an improved earth road that are permanent improvements. They are: (1) The establishing of low maximum grades; (2) straightening or correcting the present alignment of the road, and (3) building permanent structures.

The establishing of a low grade and the determining of proper alignment of the road are important and are products of considerable study in the preparation of plans.

The laying out of the grades and center line for the guidance of the contractor by the project engineer has been one of the chief sources of discussion between the engineer and contractor during the present season.

The project engineer must cross-section his work ahead of the contractor, adjusting the grades where an excess or under-run of dirt encountered; give slope stakes for the guidance of the contractors; stake out structures and inspect same; prepare weekly and monthly reports, and also submit his monthly estimates. He is, therefore, a busy man and, unless he keeps well ahead of the contractor, grief is his portion.

This year, we are going to avoid these troubles by getting out parties early on their work; having them carefully check all of the bench marks established by the preliminary parties; set new benches where required, and then set a row of stakes at least 100 ft. apart where they will not be disturbed during the progress of the work by tenants living along the road. These stakes will have marked upon them the station, the distance from the face of the stake to the center line and the cut or fill from the top of the stake to the finished center of the road.

The project engineer will also be required to mark all trees and brush that are to be removed and see that the clearing is at least 1 mile ahead of the contractor. He will also mark each telegraph or telephone pole with a distance right or left that it must be moved to clear the work, and finish negotiations concerning the removal of these obstacles with the company that owns them so that no delays will be suffered by the contractors and the owners will have ample time to remove the poles.

The most important matter in the construction of earth roads is the finish. After the work has been brought to grade, roughly, finishing stakes are set by the engineer and the contractor blades his road continuously until a smooth, compact surface is secured, as indicated by the stakes.

A question that always arises when the subject of earth roads is discussed is, how are you going to finish your back slopes, especially are you going to require hand dressing? This is answered very easily. If a contractor is careful he can slope his cuts in such a way that the terraces made by his disk are so slight that the action of the weather will soon put them in satisfactory shape. Other contractors are sloppy and butcher their work in such a way that the mattock is the only tool that will correct their rough back slopes. It is not our intention to require hand work on back slopes and if the contractor will use reasonable care he can avoid it. There are several attachments for an elevating grader that will cut back slopes—some of these have been recently patented and will be put on the market. It is also possible to cut slopes up to 6 ft. with a blade grader.

The finish of a road is important, for the verdict passed by the traveling public, whether a road is good or bad, is based entirely on how it rides and how it looks.

Comparison of Truck and Team Haulage.—A recent issue of the Oklahoma State Highway Bulletin gives an interesting comparison with regard to team versus trucks in the hauling of road building materials. A road contractor while doing state aid road work of hauling crushed stone, employed seven teams, seven drivers, and one 3½ ton truck. The seven teams had each hauled three loads of 1½ yd. per day, a total of 4½ yd. daily. By truck he hauled 33 yd. each day. Figuring the cost of each team and driver at $7.25, the total amount was $50.75 per day for seven teams. The 3½ ton truck actually hauled more material each day than the seven teams. The operating expenses of the truck figured to $18.40 per day, thereby effecting a daily saving of $32.35. The distance of the haul was 4½ miles each day, or a total of 9 miles.

211 Miles of Road Work Let in Missouri.—Since Jan. 1 the State Highway Department of Missouri has let contracts for the construction of more than 211 miles of improved highways with state and federal aid. This figure covers work let up to April 15. The department has 800 more miles that have been approved by the government and are ready for the letting of contracts. The total estimated cost of the thirteen projects is $2,038,041, of which $823,121 is federal and $284,322 is state.

Motor Policemen for State Highways.—The California State Highways Commission in its 1919 annual report suggests legislation for the establishment of a system of motor policemen for state highways, as means of preventing damage to the road surfaces by overloaded trucks.

Method of Estimating Labor Hour Requirements on Paving Work

By D. B. DAVIS,
City Civil Engineer, Richmond, Ind.

In estimating the cost of paving work, while the labor market is constantly changing from month to month, estimators who have an indefinite knowledge of the labor hour requirements for the divisions of work necessary, are liable to have their estimates incompatible with the true value of the work. A knowledge of the labor hours necessary to do a certain work together with accurate market price quotations on the materials which enter into it, will give the estimator much more faith in his estimates.

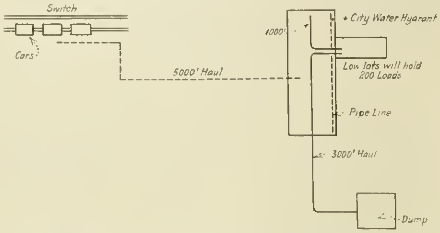


Fig. 1—Sketch Showing Various Conditions Relating to Paving Job.

Although it is commonly conceded that engineers' estimates, on the whole, are not derived from as close a study of the details of the work as a contractor would give to it, there is reason to believe that if a closer study of conditions were made there would be less disparity between their estimates and the contractors' bids.

In making an estimate of a certain work a chart showing the various conditions relating to the work will help to guarantee against omission of important details. This chart can be a rough sketch, which in case of a brick paving job in a city, will show the length of haul from the nearest switch to the job; the length of haul from the closest dump to the job; the kind and nearest water supply and other matters of interest one will record on making an inspection of the site. An example of a chart of this kind is shown in Fig. 1.

A brief study for determining the labor hour requirements for some divisions of work connected with a brick paving job in a city will be undertaken.

The excavation in this case will be assumed to be completed.

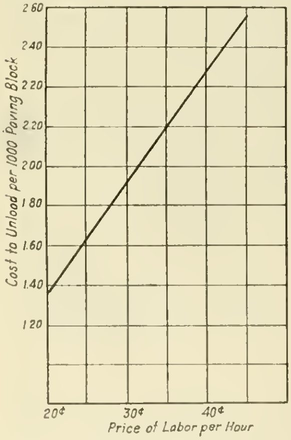


Fig. 2—Cost of Unloading Brick from Cars and On Job.

Assumption: 5.7 labor hours per M.

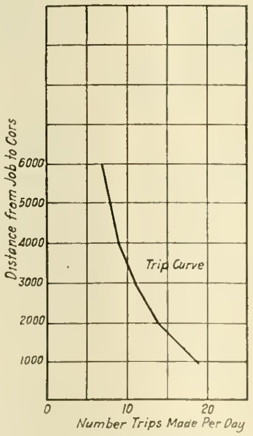


Fig. 3—Curve Showing Number of Loads Per Day.

Extra wagons provided to prevent idle time of teams.

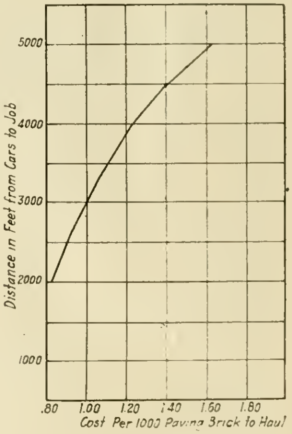


Fig. 4—Cost of Hauling Brick.

Team, $8 per day; 665 brick to load.

To estimate the cost of unloading and hauling brick from the cars to the job, it is first necessary to figure on the cost of unloading them. It has been the experience of the writer on a number of his jobs that a working unit consisting of five men loading from the cars to the wagons and six men at the job, unloading these wagons as they come, will unload approximately on an average of 19,300 paving brick in a 10-hour day. Or it requires approximately 5.7 labor hours to handle the brick from the cars to the pile. Figure 2 shows the cost to unload brick to the pile at different rates of wages for labor.

To haul the brick from the switch to the job, extra wagons are provided, so that the teamster after having hauled the loaded wagon to the street to be unloaded can immediately hitch to an extra empty one and proceed back to the switch. In this way no team time is lost while waiting for loading or unloading the wagons.

The number of loads that can be hauled in a given length of time can be determined by the formula:

$$\text{Number of loads hauled} = \frac{T}{\frac{L}{r} - z}$$

In which T = total working time in minutes.
L = length of haul (round trip).
z = lost time in minutes, unhitching, etc. (this will average 17 minutes).
r = rate of team travel (180 ft. per minute).

Figure 3 shows this formula plotted for different lengths haul.

Now to find the teams required; find from Fig. 3 the number of trips per day corresponding to the length of haul. Then the number of trips × the capacity of each load equals the number of brick that one team will haul. Then

$$\frac{19{,}300}{\text{number brick hauled by one team}} = \text{number of brick required.}$$

Figure 4 shows the cost of hauling brick for various lengths haul. In this case team hire is figured at 80 cents per hour and the capacity of each load at 665 brick.

The total cost of handling and hauling the brick may be found by adding the values from Figs. 2 and 4.

To estimate the labor required to lay a concrete base 6 in. thick the required organization should first be outlined. Such an organization, where the concrete mix is 1 part cement and 7 parts gravel and a 1-sack steam chute mixer is used, is as follows:

1 engineer mixer.
1 fireman mixer.
2 concrete spreaders.
1 handling cement.
3 gravel wheelers.
3 gravel shovelers.
1 water boy.
1 foreman.

This gang will lay concrete base requiring approximately

0.20 labor hours per square yard. Figure 5 shows values platted when using a 1-bag chute, 1-bag boom and an old-style non-traction mixer which requires men to wheel the mixed concrete from the mixer to the bed.

To estimate the labor required to lay the brick in the pavement, it is well to remember the divisions of labor required. For the ordinary city pavement it will require five divisions. The following table gives these divisions with coefficients relating to each:

Sand bed mixers	0.00742
Brick carriers	0.01320
Brick setters	0.00214
Batting in closures	0.00200
Cement grouting, by hand mix	0.00797
Cement grouting, machine mix	0.00460

To find the number of men needed for each division of work to balance the whole gang, multiply the required output by the factors opposite each divison in the table and take the closest even number.

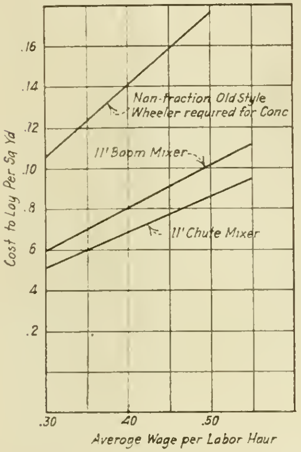


Fig. 5—Cost of Laying 1:7 6 in. Concrete Base.

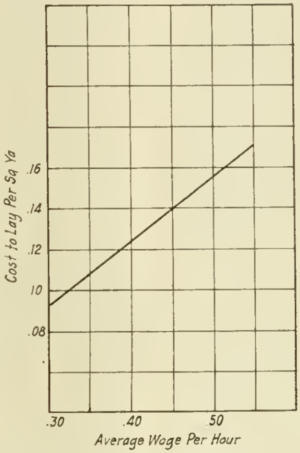


Fig. 6—Cost of Laying Brick.
Includes preparing sand-bed, carrying brick, laying brick, batting inclosures and foreman. Assumption: .31 labor hours per sq. yd.

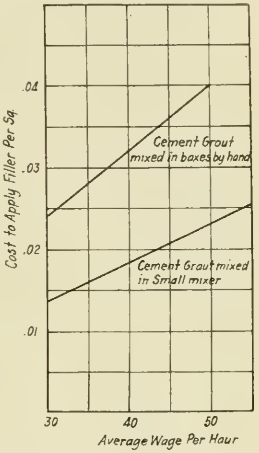


Fig. 7—Cost of Applying Filler to Brick Pavement.
Assumption: Mixing by hand, 0.080 hours per sq. yd.; mixing by machine, 0.046 hours per sq. yd.

For example, to find the number of men needed to carry brick in order to lay 1,000 sq. yd. in 10-hour day: Multiply 1,000 yd. by 0.0132, which makes 13.2 or 13 men needed.

Figure 6 shows the costs of laying brick in pavements at different rates of wages. It is figured on the assumption that the operations named require 0.31 labor hours per square yard.

Figure 7 shows the cost of applying cement grout filler. The lower line shows the cost when using a small grout mixer and the upper line shows the cost when using the old-style grouting boxes, which require mixing by hand. With labor at 50 ct. per hour it can be seen that a saving of 1¾ ct. per square yard is made by using the gasoline grout mixer.

The labor hours required for these various operations were obtained from the writer's experience and represent work that has been done by energetic, enthusiastic workmen. The proximity which another gang could approach these values would depend wholly on the morale of the workmen and the experience and "pep" of the man in charge.

Texas Awards Highway Contracts Totaling $4,225,000.—Contracts for $4,225,000 of new construction on the state highways in Texas had been awarded this year up to April 15. The 261 miles includes 31 miles of concrete pavement, 59 miles of bituminous surfaced roads; 151 miles of crushed rock or gravel surfacing and 20 miles of shell.

Nearly $2,000,000,000 Worth of Horses on Farms.—On Jan. 1, 1920, the Bureau of Crop Estimates of the U. S. Department of Agriculture estimated the total value of horses on farms in this country at $1,993,000,000, or just a little below the value of milk cows, which was $2,022,000,000.

Wisconsin Experiences in Road Building and Maintenance*

By A. R. HIRST,

Chief Engineer, Wisconsin Highway Commission.

When I went into Wisconsin in 1907, I went there with the idea that any money which was not spent for construction was wasted. I am now just as firmly convinced that we can spend our first several million dollars in temporary work in making these roads passable, not in 1950, but in 1920. The proper thing to do is to make the whole system passable, and then come along and put on the fancy touches a little later. That is our theory: That we will first make our main roads passable; and, in the second place, we will build them just as fast as we can furnish the money and labor and material.

I call our divisional engineers several times a year into conference, and last year, after two years of patrol service, I asked the eight engineers to place on a sheet of paper what they honestly believed was the saving in time on the state roads in 1919 as compared with 1917. They estimated that they could travel at 15 miles an hour in 1917; and at the end of 1918, 22 miles. In other words, two years' maintenance work has added 7 miles per hour to the speed of the traffic on these roads, and it has not cost us hundreds of millions of dollars. It has cost us in the two years about $400 per mile.

Patrol System of Maintenance.—On earth roads the patrol sections are from 6 to 10 miles. That is a horse or team patrol. This man is given a road cleaner and a 2-horse blade grader or road machine that a man can both operate and drive. We have found that for earth road maintenance, this one man road grader is the most valuable tool, and the second most valuable tool is what is known as the Minnesota planer. We have, for all practical purposes, discarded the King road drag as a maintenance tool. We found that they had a tendency to make our grades too rolling, while the long road grader, with two parallel blades and with two or three cutting bars 16 ft. long, bridges the gaps and fills in the holes, and we get a much more easy-riding road.

We started the patrol system in the spring of 1918. We put on about 700 patrol men for 5,000 miles of road. In the fall of 1918, the very first year, about 15 of our counties selected what we call the county trunk system and put patrol men on them. They were so impressed with the first year's operation of this patrol system of maintenance, that about 15 counties established the patrol system on their secondary roads or improved county roads. Last year we maintained about 5,000 miles of state trunk roads and about 1,000 miles of county roads by the patrol system.

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*From an address presented March 4 at the 18th annual meeting of the Ontario Good Roads Association.

Last November 45 of our 71 counties adopted the county patrol system, and these counties will maintain this year 5,000 miles by that system in addition to the 7,500 that we are maintaining. In other words, there will be patrol maintenance in the state in 1920, of 12,000 miles of road. It seems to me that the best verdict on the success of this proposition is the verdict of the people themselves.

Last year the average pay of a patrol man with a team and wagon was $140 a month. We hired them from about April 15 to about Nov. 1. If their service is satisfactory, and if they serve until the end of the year, they are given a bonus of $5 a month, and about two-thirds of the patrol men got the bonus, which amounted to $35 or $40. This year our average scale for patrol men will be about $150 a month, with a bonus of $5 for good service.

Gravel Road Construction.—We have secured remarkable results in our gravel roads. For years we have had a large number of miles of gravel roads in the eastern part of the state. I was brought up in the Maryland highway school, and when I went to Wisconsin I devoted myself quitely largely to tellings the farmers not to waste their money on gravel roads, but to build water-bound stone macadam roads instead. I am now devoting just as much time and energy to telling them not to build any more stone macadam roads, but when they cannot build a permanent road to build a fine crushed gravel road, which we have found to be the most satisfactory. We have about 1,200 miles of this type of road. The trouble with the old gravel roads was that they were not trimmed carefully; the ridges were there because no special means were taken to get rid of them, and no effort was made to take out the large stone. We are now crushing all the gravel used on our roads, so that it will not exceed 1 in. in size, and if we could find a crusher that would crush it down to a ½ in., that is how we would use it for the top 3 in. of the road.

The old standard used to be that any gravel that was fit for roads should be filled so full of clay that it stood vertically in the pit; and that any gravel road that did not consolidate readily under the roller was not fit to build. We have found that the kind of gravel that can be used on different roads varies exactly as the soil upon which it is placed. In other words, on a heavy clay soil you want a sandy gravel, and if it does not consolidate for six or eight months, there is no cause to worry; it has been our experience that the longer it takes to consolidate, the better wearing surface you are going to have.

On a sandy base you want a clay gravel, the difference being that on a clay base the gravel is pushed down and in by a capillary action. On a sandy base you cannot use sandy gravel because there is none of that action which will finally consolidate it. These are things that we have found when we get gravel roads: First, the finer the gravel is, within reasonable limits, the better; second, that a sandy gravel is the best to place upon a heavy clay base; and third, that clay gravel is the best for a sandy soil.

We used to specify that every gravel road should be rolled until it was compacted. After two years, we do not specify that our gravel roads should be rolled at all. We finish our gravel roads in what we consider a much better way, under the patrol and maintenance system, by having a patrol man constantly go over them and work them with a road machine and road planer and allow the travel to compact them little by little.

At the end of a few weeks, or months at the most, we get a surface which is much better than the surface which we get by rolling. It must be conceded that they are a little inconvenient to travel on for a few days. We put on about 8 miles of sandy gravel on an old clay road near Madison last year. It cost us about $800 a mile. Given constant attention by patrol maintenance, 2 or 3 in. of fine crushed gravel will make a wonderful road if you build it wide enough.

Application of 2 to 3 in. of Sand on Clay Produces Good Road.—About three years ago I went up into one of our counties where we were building a gravel road. It was late in the fall, just before the freeze up, and I found 20 miles of sand about 3 in. deep on top of Lake Superior red clay. I could not get in touch with the county highway commission, and I guess it was a good thing I could not, because my language would not have been parliamentary, but I wrote a letter which is still preserved in the archives of that county, to the effect that any man who would assume that that was a road, did not have any brains. The material was nothing but sand; there was nothing in it larger than ¼ in.

The next spring I went up there again, and found that that stretch of road was (and still is, after three years), one of the finest stretches of road in the state. Our speed limit of 30 miles an hour is not sufficient on that road. I consider that is one of our most valuable discoveries: That a light application of 2 or 3 in. of sand on clay will produce a road which is wonderfully satisfactory to travel over a good many months in the year. Now, I do not claim that this 2 or 3 in. of sand will hold up a 12 or 15-ton motor truck in the spring. That kind of road is not designed to do that. In some cases these roads become impassable if used by trucks, but they can be whipped back into shape as soon as the weather permits them to dry out. Put the road down 18 or 20 ft. wide, and make it 3 in. thick in the center, going out to a feather edge, and put the planer or road machine on it for a few days or few weeks until the travel consolidates it, and I will guarantee that you will be astonished at the result.

The water-bound stone macadam road has given us an infinite amount of trouble. We built many hundreds of miles of it 9 ft. wide, and as soon as the automobile travel came, it unrivalled these roads and they went all to pieces. We then started to treat the surface with tars and asphalts, and after one or two treatments, we found that these narrow surfaces got very rough. At the present time the roughest roads we have in Wisconsin are our water-bound macadam surface-treated roads, and we have practically given them up. We are now scarifying these old 9-ft. macadams down a good depth, spreading them out to 15 or 16 ft., and putting on top of them 2 or 3 in. of fine, crushed gravel, and maintaining them as gravel roads. We can do that much cheaper than we can surface-treat them, and they are much more satisfactory. This is especially the case if there is sand in the gravel. I say sandy gravel, for the reason that a clay gravel is dusty; it is inconvenient and a nuisance, whereas sandy gravel is very seldom dusty, and will give very little trouble after it is down two or three days or a week, while the clay gravel will always give trouble.

Three Types of Roads Being Built.—We are endeavoring to build and maintain practically only three classes or types of road. First, the earth road—not necessarily the earth road as the Lord put it there, but as we have improved on His handiwork. I mean that where it is a sand earth road, we cover it with clay as fast as we can get it there. We find that this clay top—3 or 4 in. of it—will give us a very satisfactory road on a sand base. Where the road is too clayey, we put 2 or 3 in. of sand on top of the clay, and it makes one of the best earth roads you can have.

If we have a place where the earth road absolutely fails to serve the traffic, and if we cannot build any of these expensive new types of road, we are building almost entirely gravel roads if we have gravel in the neighborhood. Where we have not money enough to build what we think is the final type of road, we build what we call semi-penetration stone macadam; that is, we build the old water-bound macadam road up to about the point where you commence applying the water, and we then put in about 1½ gal. of tar or asphalt, finishing first with coarse screenings and then with fine screenings, and then about ¼ gal. of asphalt or tar and finish it off with chips. We build these roads only where we cannot get gravel and where we cannot afford to build the final type.

For roads which are ultimately going to take over a heavy truck traffic, which are really state trunk highways, main market roads and main commercial roads, especially in congested districts, there is no road which will give the ultimate service like the concrete road or a road on a concrete base. I am convinced of that from what I have seen in several states, and my experience of 16 years tells me that the ultimate road for heavy traffic must be the concrete road or another top surface on a concrete base. These roads in Wisconsin are costing us today between $30,000 and $50,000 a mile. The gravel roads in our gravel districts are costing us about $8,000 a mile for 15-ft. and 16-ft. roads, and in a great many cases we are building the $8,000 roads and letting the $30,000 and $40,000 roads wait, because we think we can figure out on the basis of pure economics that the cheapest road may after all be the most economical road in certain cases.

Standard Form for Estimating Costs of Highway Work

A standard estimate sheet intended to include, or at least suggest, all items which might be considered as a proper cost charge in any of the operations which are likely to occur in road and bridge work in Wisconsin has been developed by a committee working under the direction of the state highway department. The form has been drawn up as an aid for the state highway engineers in estimating for proposed improvements, and for the use of contractors in preparing their bids. In submitting the cost estimate sheets the committee gave the following explanatory remarks regarding their preparation and use:

The percentages which are shown under the heading of "Machinery and Equipment" as representing proper charges to take care of depreciation, upkeep, interest, storage, insurance, etc., were arrived at after considering all of the available information on the subject, but there was so little information of actual value that these percentages can only be taken as an approximation of actual conditions.

It is felt, however, that the average contractor, unless he has better information at hand, cannot go very far wrong in using these values. It must be kept in mind that we have included in these cost sheets every possible item that we could think of connected with this class of construction, and consequently the person using these sheets must remember that in arriving at his costs he is to make entries only opposite those items which directly concern him.

There is possible danger in the case of the average person using these sheets of duplication in certain items. For example, in the case of the Grading, Item No. 7, under the sub-heading "Excavating Earth, Light" the cost of the men and teams used in the operation is the only cost to be entered. The cost of any moving of any camp equipment should not be included, or the cost of any machinery, depreciation, etc., for the moving costs are to be taken care of under heading No. 1, "Moving Equipment," and the depreciation, upkeep, etc., of machinery and equipment are to be taken care of under heading No. 16.

At the right-hand side of the sheets you will find columns headed "Paving," "Grading," "Culverts and Bridges," "Miscellaneous," and "Totals," and in making the estimate of cost the items properly chargeable against each of these divisions should be entered in their proper places. That is to say, in the case, for example, of the items of "Moving to Job" under heading No. 1, "Moving Equipment," the part of this cost which is chargeable against "Paving" should be entered in the "Paving" column, and the part chargeable against "Grading" in the "Grading" column, etc., and the total costs for each of the items, "Paving," "Grading," etc., must be obtained by taking a total of all of the items in these columns, and it cannot be obtained in any way from the fifth column, which is headed "Totals," which is placed there principally for the purpose of getting a cross check on the additions.

Under each of the main items, such as "Moving Equipment," "Cement," etc., just above the word "Total" you will find a blank line, which may be used to enter in any item which is not actually listed. It must be borne in mind that in making the entries under the different headings the estimator should arrive as nearly as possible at actual costs, because the unforeseen difficulties and contingencies that may arise on his job are to be included under heading No. 10, and should not be duplicated by entering in any other place.

You will note that under the item "Overhead," No. 12, we have indicated that certain percentages of salaries, expenses, rentals etc., are to be charged. This simply means that if the job is a full year's work a full year's salary, expenses and rentals will be charged, but otherwise you are to charge only the proper percentages of the yearly costs.

In arriving at the percentages under the heading "Machinery and Equipment," "Estimated Depreciation," "Upkeep," etc., in the column "Rate Per Mile" the amounts were determined on the basis of an outfit capable of building 6 miles of 18-foot concrete pavement per year. Remember that the amounts entered under this heading include not only what is ordinarily called depreciation, but also all repairs to the machinery, interest on investment in machinery, insurance, storage, etc. For outfits which would build either more or less than this, certain of the percentages would change slightly, but we believe there would be no great differences from the amounts shown.

In general, we believe that the main point to be guarded against in the use of these cost sheets is that of duplication. Look over the sheets carefully before starting your estimate, and note that the different units that enter into costs are separated into well-defined groups.

In the past it has been common in the case of grading work for a contractor to estimate the work at a certain cost per cubic yard, which included all such items as Moving Machinery, Depreciation, Upkeep, etc., Labor, Teams, Lost Time, etc., and to apply a certain percentage of profit on this and offer it as the bid's price. With this form of estimate he cannot do this. He must put his moving costs under the item of "Moving Equipment" and all of the other costs in their proper places, putting under the heading "Cost of Excavation" only the cost of men and teams.

If the estimator will keep these facts in mind in preparing his estimate of cost on any job we believe that he will arrive at a figure which is more nearly representative of actual cost than the figures which have usually been submitted in the past.

The cost estimate sheet follows:

Operation.	Paving.	Grading.	Culverts and Bridges.	Miscellaneous.	Totals.
1. Moving Equipment.					
Hauling from shed to cars					
Cost of loading					
Freight charges					
Cost of unloading					
Moving to job					
Lost time of equipment					
Cost of erection of camp, including water supply					
Cost of transptg. teams or trucks					
Cost of return of above					
Total—(In total column)					
2. Cost of Rental of R. R. Siding					
3. Cement, Cost Per Bbl., f. o. b. cars at					
Number of barrels					
Cost of unloading and storing					
Cost of hauling and covering					
Fire insurance on cement and empty sacks					
Sack loss, 2 to 5 per cent					
Freight return of empty sacks					
Demurrage					
Total—(In total column)					
4. Fine Aggregate.					
No. of cu. yds., including waste.					
Average price per cu. yd., f. o. b. pit or quarry					
Freight and demurrage					
Cost of labor, unloading					
Cost of hauling to job					
Labor and horses					
Cost of spotting on job					
Rehandling from stock pile					
Total—(In total column)					
5. Coarse Aggregate.					
No. of cu. yds., including waste.					
Average price per cu. yd., f. o. b. pit or quarry					
Freight and demurrage					
Cost of labor, unloading					
Cost of hauling to job					
Labor and horses					
Cost of spotting on job					
Rehandling from stock pile					
Total—(In total column)					
6. Surfacing.					
Rolling subgrade					
Cost of joint material delivered on the job					
Labor mixing and placing concrete, including engineer, firemen, form setters, fine graders, wheelers, shovelers, cement men, puddlers, baling and sorting sacks, curing, covering and uncovering, finishers, water boy, watchmen, barricade and lights					
Foremen ...... days at					
.....men ...... days at					
.....men ...... days at					
.....men ...... days at					
.....men ...... days at					
Pumping and water supply (labor, connecting pipe, setting pump, operator, fuel, disconnecting pipe and drilling well.					
Gasoline, coal, oil, etc					
Cost of hiring, shipping in men and loss in running camp					
Purchase of hardware, lumber, boot, etc.					
Rent of water, buildings, warehouse, grounds, etc					
Cost of building cross-overs					
Total—(In total column)					
7. Breaking and Moving Dirt and Rock.					
Cost of—					
Staking					
Keeping road open to travel					
Clearing					
Grubbing					
Excavating earth, light—Men and teams only					
Excavating earth, heavy—Men and teams only					
Excavating rock, loose—Men and teams only					

Operation.	Paving.	Grading.	Culverts and Bridges.	Miscellaneous.	Totals.
Excavating rock, solid— Men and teams only					
Dynamite					
Sloping					
Trimming					
Shoulders					
Ditching					
Moving, enter under No. 1					
Equipment, etc., enter under No. 16					
Total—(In total column)					
8. Culverts and Bridges.					
No. cu. yds. in job					
Moving equipment, enter under No. 1.					
Labor, enter under No. 6					
Mat'l, enter under Nos. 3, 4, 5					
Labor excavating, removing of old structures, building forms, removing forms, placing concrete					
Detours or temporary bridges					
Piling					
Cofferdams					
Expansion joints					
Waterproofing					
Drains					
Cost of steel					
Cost of lumber					
Total—(In total column)					
9. Guard Rails.					
Posts					
Lumber					
Paint					
Hardware					
Creosote					
Labor					
Hauling					
Total—(In total column)					

10. Unforeseen Difficulties.					
Delays due to railroad embargoes, strikes at pit or jobs, material plant breakdown, breakdown of machinery, failure of water supply, bad weather, pipe line breaks and freezing					
Total—(In total column)					
11. Compensation and Public Liability Insurance (labor only)					
12. Overhead.					
Per cent of manager's yearly salary					
Per cent of yearly salary of stenographer and clerk					
Per cent of yearly salary of material man and timekeeper					
Per cent of yearly expense of manager					
Auto, ... miles at 12 ct.					
Railroad fare, hotel, meals					
Bidding cost, conventions, associations					
Per cent of yearly office rent					
Per cent of yearly office telephone and telegrams					
Per cent of office supplies, miscl.					
Corporation insurance					
Interest on borrowed money					
Total—(In total column)					
13. Bond Cost (Personal or Surety)					
14. Total Net Cost of Job					
15. Profit for each class of work, as paving, grading, etc					
Plus depreciation on equipment as listed below					
Amount of bid					

TOTAL AMOUNTS CHARGED OFF.

	Original cost.	Rate per mile. Per cent.	No. miles.	Total % charged off.	Paving.	Grading.	Culverts and bridges.	Misc.
16. Machinery and Equipment.								
Estimated depreciation, upkeep, interest, storage, insurance, road rollers, etc		2-4						
Mixers		6						
Finishing machine		7						
Sectional storage bins (erecting cost, No. 1)		7						
Special storage bins, material and labor (charge full cost)								
Clamshell crane		4						
Stiff leg derrick (erecting cost at No. 1)		4						
Two pumps		6						
Pipe line, ... miles (include laying cost at No. 6)		6						
Side forms, ... feet (steel), material only		12						
Side forms, ... feet (wood), material only		27						
Iron stakes, material only		15						
Ford car (1 camp car), including operating costs		16						
Ford car (1 service car), including operating costs		16						
Canvas		10						
Hose		16						
Wheelbarrows		10						
Locomotive		6						
Cars		6						
Track		2						
Batch boxes		10						
Concrete roller		20						
Strike-off board (charge full cost to job)								
Mixer loaders (belt conveyor)		12						
Wagon loaders (erecting cost at No. 1)		7						
Camp equipment (stoves, bedding, bunks, camp on trucks, etc.)		8						
Small tools (charge full cost to job)		16						
Totals								

TOTAL AMOUNTS CHARGED OFF.

	Original cost.	Rate per day. Per cent.	No. operating days.	Paving.	Grading.	Culverts and bridges.	Misc.
Totals brought forward							
Wagons (plain)		½					
Wagons (dump)		½					
Trucks		½					
Wheel scrapers		½					
Fresnoes		½					
Slushers		½					
Graders (heavy)		½					
Graders (light)		½					
Plows—		½					
Rooter		½					
Medium		½					
Light		½					
Heavy		½					
Steam shovel, including fuel, oil, etc		½					
Elevating grader		½					
Maney wheel scrapers		½					
Steam drill		½					
Compressor		½					
Tractors		½					

Iowa's Road Contractor's Bond Performance Measure.—The bond required by the Iowa State Highway Commission from road contractors is so drawn as to emphasize the fact that the bond is to be considered a performance bond and not a maintenance bond. The bond gives to the county the right of recovery against the use of defective materials and poor workmanship. It also guarantees faithful compliance with plans and specifications. The contractor is not asked to assume the responsibility for maintenance of the paving constructed in accordance with these plans and specifications.

Atmospheric Sanitation*

By C. S. DALE.

"Asmospheric Sanitation," the title given this discussion on the program, is used to designate a subject which most of us commonly refer to as smoke abatement. The title has not been used to confuse or perplex, but rather to make clear at the outset that the problem of purifying the air of our cities involves much more than the abatement of smoke. Smoke is only one of several sources of atmospheric pollution, although it is the most important single source.

In every city where the activities of industrial and community life proceed upon any considerable scale, the atmosphere becomes saturated with foreign matter which constitutes a variety of impurities. The presence of these impurities is damaging to property, injurious to health, harmful to vegetable life and altogether undesirable in times when cities are beginning to take pride in their cleanliness and beauty.

The need for better and cleaner air in our cities is apparent to all. Even the smaller cities and towns are suffering from the effects of air pollution. City officials have given attention to it and in many cases ordinances have been passed prohibiting the discharge of smoke into the air. Many such ordinances are in effect today, and they are generally being enforced with admirable skill and good judgment.

But so far nearly all legislation having for its purpose the purification of the atmosphere has been directed against smoke. Little serious attention has been paid to other sources of atmospheric pollution such as street dust, building dust, rubbish heaps and others, examples of which will be shown. There is, however, a marked distinction between the methods which may be successfully employed to abate smoke and those which will serve to eliminate other sources of pollution. The problem of smoke abatement is both an engineering and an educational problem; that of dealing with other sources of atmospheric pollution is a problem in municipal housekeeping.

Smoke abatement at present is a matter possessing all the importance which has heretofore been normally attached to it plus the advantage of serving as a direct means of conserving fuel. It therefore has its old aspects a municipal problem and in addition has newer aspects as a national problem. As a means in fuel conservation, I do not place emphasis upon the possible recovery and utilization of heat units which may be contained in the smoky discharges from chimneys and stacks, but point rather to the obvious fact that the process of bringing about the abatement of smoke does and, to be successful, must involve a better understanding, on the part of firemen, owners, or operators of fuel consuming plants, of the principles of good fire-room practice. And better fire-room practice means fuel economy.

In dealing with the smoke nuisance it has usually been the custom to consider only the visible aspects of smoke. Ordinances therefore have sought to prohibit the emission into the air of "dense" smoke, "black" smoke, "dark" smoke, "dense gray" smoke, "thick gray" smoke, etc. The prohibition of noxious gases and offensive odors is included in the case of a few ordinances, but no satisfactory definition of these is given. Of all smoke abatement ordinances of the present time it may be said, therefore, that while the general purposes sought are evident enough, the definite basis upon which they may be enforced is lacking. Dense gray smoke to one inspector or observer may be classed as light gray smoke by another. Furthermore, smoke abatement ordinances have generally been merely prohibitory in their terms. But those to whom has fallen the task of administering the law have found that a mere order to "stop making smoke" does not get results. Smoke inspectors found that there were only two ways to prevent smoke; either put out the fires or educate plant owners and firemen in the design, installation and operation of fuel consuming plants. The problem became at once an engineering problem and an educational problem. It was found that to abate smoke changes often had to be made in boilers and always in operating methods and conditions. Individual plants had to be studied and individual instruction given.

The present situation in the fuel market is such that practically the only fuel available for use in Illinois is bituminous coal. It must be accepted and used for residences and apartment buildings as well as for industrial purposes. This condition still further complicates the smoke problem, because house heaters which burn pocahontas or anthracite satisfactorily generally require much greater care and more frequent attention when bituminous coal is used. Without undertaking a detailed discussion of furnaces and heaters, and their operation, it may be said that smokeless combustion of bituminous coal, and its economical use, involves compliance with certain definite principles:

1. The fresh coal should be introduced into the fire-box at such a point and distributed in such manner that the combustible gases distilled from it will be required to pass over incandescent portions of the fire or over surfaces which are maintained at a high temperature. Observance of this principle promotes the ignition and combustion of the distillates.

2. The steam of gases arising from the fresh fuel must be heated quickly and must be kept at a high temperature until the process of combustion is well advanced. The use of a fire-brick arch, under which the distillates may be burned, is an aid in securing this condition.

3. An ample suuply of air, under proper control, should be available to aid the combustion of the gases which arise from bituminous coal.

4. The proportions of the furnace and the fire-box should be such as to provide an ample flame-way. This condition is necessary in order to allow sufficient time for the burning of the gases. The length of flame-way in many types of furnaces may be increased by the use of baffle walls or arches.

With reference to the broader phases of atmospheric pollution, in which every city official is interested, it should be recognized that:

1. Smoke has three distinct characteristics to each of which a suitable standard of measure may be applied. These are:

(a) Visible properties.
(b) Solid particles.
(c) Gaseous products.

2. Smoke is responsible for only approximately two-thirds of the pollution in the air, the remaining one-third having its origin in sources the disposition of which is a relatively simple and inexpensive matter.

By "visible properties" of smoke are meant those properties which impart visibility to it or make it apparent to the eye. Public interest has been centered in this aspect of smoke, and it has been assumed that a chimney which did not give forth a discharge visible to the eye, was not a source of atmospheric pollution. This assumption is not borne out by the facts. Tests have shown that stationary plants discharging through the smoke stack as much as two per cent of the fuel fired, may appear smokeless to the eye. On the other hand it has been shown that stacks recording a smoke discharge of high visible density may be emitting in the form of solid particles only a small fraction of one per cent of the fuel fired. Thus there is apparently no relationship between these two aspects of smoke. Both are objectionable. Visible smoke is offensive to the eye and solid particles or dust from smoke stacks is injurious to property, to vegetation and to animal life. In densely populated cities the discharge of solid particles amounts to about 600 tons per square mile per annum; even in cities of moderate size the deposit is as much as 300 or 400 tons per square mile per annum.

In determining the extent of the smoke nuisance created by any fuel consuming plant or the amount of smoke emitted from the smoke stack, the relation between the amount of fuel fired and the discharges through the stack is studied. Discharges may be rated according to the Ringelmann method (visible smoke) or they may be analyzed to determine their physical and chemical properties by means of filtering and sampling apparatus designed for the purpose. The correction of the smoke nuisance is very largely a matter of improving the practice in each individual plant. While the plant owner should be made responsible, the city official should not fail to give proper advice based upon a knowledge of conditions.

While the abatement of smoke is a problem involving expense, study and the constant attention of a competent engineer, there is much that city officials may do to help purify the atmosphere by merely seeing that municipal housekeeping is well done. More than a third of all the dust and dirt in the atmosphere of the average city has its origin in poorly cleaned streets, in the careless handling of materials in transit, in street construction, in unimproved streets and alleys, in building operations, in neglected backyards and roofs, in rubbish heaps, and in vacant lots.

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*From a paper presented before the Illinois Municipal League.

Recent Developments in Concrete Road Construction*

By A. N. JOHNSON,
Consulting Highway Engineer Portland Cement Association.

Subgrade.—The employment of machinery makes possible refinements which would not be otherwise practicable. The preparation of the subgrade is an example in point. More study and care should be given this part of the work. I agree with those engineers who have expressed the opinion that the subgrade should receive little or no rolling. This is particularly true for heavy clay and gumbo soils. In general it is recommended that the subgrade should be brought to within 1 or 2 in. of the desired elevation. The side forms should then be accurately set and the remaining portion of the subgrade carefully scraped or honed to the exact contour and elevation. This may be accomplished by a grading machine, which has been recently put upon the market, which may be operated so as to bring the road bed to as nearly true a surface as is desired for the surface of the concrete, which is as it should be.

On those subgrades, in clay soils particularly, where drainage is especially precarious and upon certain types of heavy gumbo soils which undergo considerable change with the variations between dry and moist conditions, it is recommended that a layer, 3 or 4 in. thick, of cinders, sand, fine gravel or similar material be placed, upon which is laid the concrete.

Broad, flat shoulders will help greatly to minimize movement in the subgrade due both to frost and moisture conditions. Narrow shoulders bordered by deep ditches is a condition to be avoided.

Joints.—There is an increasing tendency on the part of many engineers to omit entirely expansion joints in the construction of concrete roads and there has accumulated ample experience to justify such practice. The chief advantage gained by omitting expansion joints is the avoidance of an uneven surface at the joints which often occurs unless extreme care is taken to place the joint and to finish the concrete surface in the immediate vicinty.

Reinforcement.—The use of larger units of reinforcement spaced wider apart than has been the custom, is gaining some preference. Particularly has the employment of bars ¾-in. diameter laid along the edge of the pavement and cross-wise at intervals of 4 to 5 ft., proved to be a very practical and effective method. The use of reinforcement is strongly recommended for those portions of a road where the subgrade drainage is regarded as especially uncertain.

It is the practice in some localities to reinforce all the concrete in all the roads laid, but it would seem to be a more effective use of the reinforcement if it were omitted over stretches of road which were well drained, and an additional amount, over that used at present, placed in those sections of the road where the greatest difficulty is expected to obtain good subgrade conditions.

The amount of reinforcement that is used, and that it is practical to use from a cost standpoint, is not sufficient to add appreciably to the cross-breaking strength of a concrete slab. It is absolutely erroneous, therefore, to consider that reinforcement in anywise replaces concrete and that a thinner slab may be laid with reinforcement than would be laid without it. If the amount of reinforcement were 30 or 10 times as much as is customarily employed there would be some basis for such a contention. Reinforcement is useful not to prevent the formation of cracks but to prevent a crack from opening and becoming of any appreciable size; and to this end a small amount of reinforcement is effective.

Coarse Aggregate Tests.—About one-third of the state highway specifications for concrete roads prescribe that the coarse aggregate shall have a French coefficient of wear not less than a certain grade, the highest grade prescribed being 12, while other states admit as low as 6 or 7. The French coeffiecient of wear was designed as all highway engineers know, to test materials for macadam roads. The effect of traffic on pieces of crushed stone in a macadam road is quite different from that upon pieces of crushed stone imbedded in a concrete road. In the former all the pieces are subjected to wear; that is, due to the movement that occurs from the passage of a heavy vehicle the pieces of stone move and rub upon one another, thus creating what is known as internal wear. It is essential, therefore, that pieces of rock having a high resistance to wear should be used, and, because of this, it was seldom advisable to use rock in a macadam road having a French coefficient less than 12 to 14.

But in the concrete road there is no internal wear and therefore the French coefficient does not offer any criterion as to the adaptability of a given rock for concrete road work.

There are many concrete roads which have been made of aggregate having a French coefficient as low as 7, subjected to very heavy traffic and showing, after a number of years' service, very little wear; no more than many other roads constructed with aggregate having much higher French coefficient of wear. In fact, it can be stated that as between an aggregate having a French coefficient of seven and one having a coefficient two or three times as great there is no practical difference as to the wearing effect in a concrete road and that, therefore, there is no reason to exclude rock or pebbles that have a French coefficient as low as six or seven.

Tests of Sand for Organic Impurities.—Too few specifications make provision for testing sand for organic impurities. The test is so simple and can be made so readily by any engineer or foreman in the field that it is entirely practical; and, because it is of the greatest importance that no organic impurities be in the sand, such tests should be required by all specifications.

The test is made by shaking a few ounces of the sand in a 3 per cent solution of sodium hydroxide and, upon settlement over night, observing the color of the clear liquid which, if colorless or at the most a light yellow, indicates freedom of organic impurities, whereas if the liquid is a decided amber or brown it is an indication of an amount of organic impurity which should not be permitted in concrete for road purposes.

But a small amount of organic impurity is sufficient to reduce the strength of the concrete to a third or a quarter of what it would otherwise be. In fact, but a comparatively small amount of organic impurity is necessary to cause complete disintegration of the concrete.

It is oftentimes true that many sands apparently clean will contain organic impurities in sufficient amount to make them dangerous for use in concrete road work. Sands having organic impurities may be washed and in most instances most of the impurity removed, but they should be afterwards tested to make sure there does not remain a harmful quantity.

Consistency.—We have learned from the investigations of Professor D. A. Abrams of the Structural Materials Research Laboratory, Lewis Institute, Chicago, that the strength of concrete depends absolutely upon the ratio of the amount of water to the amount of cement and that the use of more water than is necessary to produce a workable consistency or plasticity is merely wasting cement and producing concrete from one-third to one-half the strength that it would otherwise have. It is therefore important that our specifications should contain some definite measure of the consistency desired. The majority of specifications at present merely describe the consistency of the concrete without providing any exact measure by which it may be ascertained.

The slump test, using a truncated cone mold, has been developed by F. L. Roman, Testing Engineer of the Illinois State Highway Department, which answers every purpose and may be readily used in the field. The method of making the test consists in filling a thin metal mold in the form of a truncated cone having an 8-in. base, 4-in. top and 12 in. high, with the freshly mixed concrete which is lightly tamped by a rod as the concrete is placed in the mold. As soon as the mold is filled and struck with a trowel it is removed by means of handles on either side and the height of the concrete after removal of the mold is measured. The difference between this height and the height of the mold, or 12 in., is taken as the slump. For concrete in concrete road work a practical consistency is obtained when the slump is between ½ in. and 1 in. Less than ½ in. gives to stiff a mixture while more than 1 in. is unnecessarily wet if the road is to be finished by a mechanical tamping machine. Where the surface of the concrete is struck by a template worked by hand it may be necessary to use a consistency corresponding to a slump of 1½ in.

In practice the application of the test will be to mix a batch of concrete knowing the amount of water used and make the slump test. Accordingly as the slump measured is too little or too great more or less water will be used in the succeeding batches.

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*From a paper presented at the last annual convention of the American Road Builders' Association.

When the proper consistency has been obtained, as noted by the slump, there is little practical difficulty to secure a similar consistency by merely noting the appearance of the concrete. The consistency which gives the highest strength in the laboratory uses too dry a concrete for practical manipulation and has a rather mealy-dry appearance, whereas the consitency containing the least amount of water which will give a workable plasticity and therefore the strongest that can be made in actual work, is one which shows barely a glisten on the particles of the aggregate as they come out of the mixer. If the concrete has an appearance wetter than this the amount of water is unnecessarily large for practical handling in road work. If no more than 10 or 15 per cent excess water is used it has cut down the strength of the concrete by nearly 50 per cent. Too great attention cannot be paid to this important point of controlling nicely the amount of water used in mixing the concrete.

ABRAMS' TABLE OF PROPORTIONS AND QUANTITIES FOR 1 CU. YD. OF CONCRETE.

Based upon laboratory investigations, using approved materials, compressive strength, 28 days, with workable plasticity, 6 by 12-in cylinders, 3,000 lb. per square inch.

SIZES		FINE AGGREGATES, SCREEN OPENINGS PER INCH														
COARSE AGGREGATES Inches	Cement in Barrels Aggregates in Cubic Yards	0-28			0-14			0-8			0-4			0-3/8 in.		
		Cement	Fine	Coarse	Cement	Fine	Coarse	Cement	Fine	Coarse	Cement	Fine	Coarse	Cement	Fine	Coarse
No. 4 Screen to 3/4	Proportions	1	1.3	2.4	1	1.6	2.4	1	1.8	2.3	1	2.0	2.3	1	2.7	1.5
	Quantities	1.96	.37	69	.85	44	66	1.82	48	62	1.75	52	59	1.79	72	40
No. 4 Screen to 1	Proportions	1	1.3	2.7	1	1.6	2.6	1	1.8	2.6	1	2.0	2.5	1	2.6	1.8
	Quantities	1.90	.36	76	1.77	42	68	1.72	46	66	1.67	.50	.62	1.72	66	46
No. 4 Screen to 1½	Proportions	1	1.2	3.1	1	1.6	3.2	1	1.7	3.1	1	2	3	1	2.4	2.4
	Quantities	1.82	.32	84	1.68	40	79	1.63	41	75	1.61	47	72	1.62	57	57
No. 4 Screen to 2	Proportions	1	1.2	3.5	1	1.5	3.5	1	1.6	3.7	1	1.9	3.6	1	2.2	3.1
	Quantities	1.75	31	90	1.63	36	85	1.55	36	.85	1.52	43	81	1.53	50	70
No. 4 Screen to 2½	Proportions	1	1.1	3.8	1	1.4	3.9	1	1.6	4.0	1	1.8	4.0	1	2.1	3.5
	Quantities	1.72	.28	.97	1.58	33	91	1.51	.35	89	1.49	.40	88	1.50	46	.78
No. 4 Screen to 3	Proportions	1	1.1	3.9	1	1.4	4.1	1	1.5	4.1	1	1.7	4.1	1	2.0	3.7
	Quantities	1.69	28	.97	1.58	33	.97	1.49	33	90	1.49	.37	90	1.49	44	.81
3/8 to 3/4	Proportions	1	1.3	2.3	1	1.7	2.3	1	1.9	2.3	1	2.2	2.2	1	2.8	1.4
	Quantities	1.96	.37	67	1.85	46	.63	1.82	51	62	1.75	.57	.57	1.79	75	.37
3/8 to 1	Proportions	1	1.3	2.6	1	1.7	2.6	1	1.9	2.5	1	2.2	2.4	1	2.7	1.7
	Quantities	1.90	.36	.74	1.77	44	68	1.72	48	64	1.67	54	.59	1.72	.68	43
3/8 to 1½	Proportions	1	1.3	3.0	1	1.7	3.0	1	1.9	3.0	1	2.1	2.9	1	2.6	2.2
	Quantities	1.82	35	.80	1.68	43	75	1.63	.46	.73	1.61	50	.68	1.62	.63	.53
3/8 to 2	Proportions	1	1.3	3.3	1	1.7	3.4	1	1.8	3.5	1	2.0	3.4	1	2.4	2.9
	Quantities	1.75	.34	86	1.63	41	83	1.55	42	80	1.52	45	.77	1.53	62	66
3/8 to 2½	Proportions	1	1.3	3.7	1	1.6	3.7	1	1.7	3.9	1	2.0	3.8	1	2.3	3.3
	Quantities	1.72	.33	.95	1.58	.37	.87	1.51	.37	.87	1.49	44	84	1.50	.51	.74
3/8 to 3	Proportions	1	1.2	3.8	1	1.6	3.9	1	1.7	4.0	1	1.9	4.0	1	2.2	3.5
	Quantities	1.68	.30	.95	1.58	.37	91	1.49	.37	.88	1.49	42	.88	1.49	.48	.77
½ to 3/4	Proportions	1	1.5	2.3	1	1.9	2.2	1	2.1	2.2	1	2.3	2.1	1	2.8	1.3
	Quantities	1.96	.44	67	1.85	52	.61	1.82	56	.59	1.75	59	54	1.79	75	.34
½ to 1	Proportions	1	1.5	2.5	1	1.9	2.5	1	2.1	2.4	1	2.3	2.4	1	2.8	1.6
	Quantities	1.90	.42	.70	1.77	.50	.66	1.72	53	61	1.67	.57	.59	1.72	.72	.41

SIZES		FINE AGGREGATES, SCREEN OPENINGS PER INCH														
COARSE AGGREGATES Inches	Cement in Barrels Aggregates in Cubic Yards	0-28			0-14			0-8			0-4			0-3/8 in.		
		Cement	Fine	Coarse	Cement	Fine	Coarse	Cement	Fine	Coarse	Cement	Fine	Coarse	Cement	Fine	Coarse
½ to 1½	Proportions	1	1.4	2.8	1	1.9	2.9	1	2.1	2.9	1	2.2	2.8	1	2.7	2.1
	Quantities	1.82	37	75	1.68	47	.73	1.63	51	.69	1.61	52	66	1.62	65	.51
½ to 2	Proportions	1	1.4	3.3	1	1.9	3.3	1	2.0	3.4	1	2.2	3.3	1	2.7	2.7
	Quantities	1.75	.36	.86	1.63	46	79	1.55	46	.78	1.52	50	74	1.53	62	62
½ to 2½	Proportions	1	1.4	3.6	1	1.8	3.6	1	1.9	3.7	1	2.1	3.7	1	2.6	3.1
	Quantities	1.72	35	.91	1.58	43	85	1.51	.42	.83	1.49	46	.81	1.50	57	69
½ to 3	Proportions	1	1.3	3.7	1	1.8	3.8	1	1.8	3.9	1	2.1	4.0	1	2.4	3.3
	Quantities	1.68	33	.92	1.58	42	89	1.49	.40	86	1.49	.46	88	1.49	53	.63
¾ to 1	Proportions	1	1.7	2.4	1	2.1	2.4	1	2.4	2.1	1	2.6	2.2	1	3.1	1.5
	Quantities	1.90	.48	68	1.77	.55	63	1.72	.61	.53	1.67	64	.55	1.72	79	.39
¾ to 1½	Proportions	1	1.7	2.7	1	2.0	2.8	1	2.3	2.7	1	2.5	2.7	1	3.0	2.0
	Quantities	1.82	.46	.73	1.79	50	70	1.63	.55	65	1.61	.59	.64	1.62	.73	48
¾ to 2	Proportions	1	1.7	3.1	1	2.0	3.1	1	2.3	3.1	1	2.5	3.0	1	3.0	2.4
	Quantities	1.75	.44	.80	1.63	48	.75	1.55	.53	.72	1.52	.56	.67	1.53	.68	.55
¾ to 2½	Proportions	1	1.7	3.3	1	2.0	3.5	1	2.3	3.4	1	2.4	3.4	1	2.9	2.8
	Quantities	1.72	.43	.84	1.63	47	.83	1.51	.52	.76	1.49	.53	.75	1.50	64	.62
¾ to 3	Proportions	1	1.7	3.5	1	2.0	3.7	1	2.3	3.7	1	2.4	3.6	1	2.8	3.1
	Quantities	1.68	43	.88	1.58	47	87	1.49	51	81	1.49	.53	.79	1.49	62	68
1 to 1½	Proportions	1	1.7	2.8	1	2.0	2.5	1	2.3	2.7	1	2.6	2.6	1	3.1	2.0
	Quantities	1.82	46	.75	1.68	.50	73	1.63	55	65	1.61	62	.62	1.62	.75	48
1 to 2	Proportions	1	1.5	3.2	1	1.9	3.5	1	2.2	3.3	1	2.4	3.3	1	3.0	2.6
	Quantities	1.75	39	83	1.63	46	85	1.58	51	.76	1.52	54	.74	1.53	68	.59
1 to 2½	Proportions	1	1.4	3.4	1	1.9	3.8	1	2.0	3.7	1	2.3	3.7	1	2.7	3.1
	Quantities	1.72	35	.86	1.58	45	.89	1.51	44	.83	1.49	.51	.81	1.50	59	69
1 to 3	Proportions	1	1.3	3.6	1	1.8	4.0	1	2.0	3.9	1	2.2	3.9	1	2.7	3.3
	Quantities	1.67	.33	.90	1.58	.42	.94	1.49	.44	.86	1.49	.48	.86	1.49	.59	.73

Proportions for Mixing Concrete.—Professor Abrams' investigations have also demonstrated that the effect of variation in the grading of the aggregate upon the strength of the concrete is due to the fact that one grading may require a different amount of water for a given amount of cement than is required for a different grading to give in each instance the same workable plasticity. From the sieve analyses he has evolved a property of aggregate which he calls fineness modulus which gives a measure of the relative grading of different aggregates. The fineness modulus he finds is such a property of the aggregate that two aggregates within reasonable limits of grading with the same fineness modulus will, if mixed with the same amount of cement and water, produce a concrete of similar plasticity and will, in a given time, attain the same strength.

He has shown further, based upon the results of many thousands of tests, that using the same proportion of cement with aggregates of different fineness moduli and securing in each instance the same plasticity; that the strength of the concrete varies as the fineness modulus of the aggregate.

The sieve analysis of a given aggregate being known the fineness modulus can be computed; and we may then determine the proportion of cement to use to produce a concrete of the desired strength. Thus it is possible and practical to make concrete of equal strength of quite dissimilarly graded aggregates. For example, one aggregate may range from 3-in. pieces to the finer sand particles, while the second may contain no pieces over 1 in. in size. Yet by varying the proportions of cement each of these aggregates may be used and the strength of the resulting concrete be the same in each instance.

This fact is of great importance as we are enabled to use a wide variety of aggregates with regard to sizes and grading. Many supplies of aggregates now excluded by the narrow restrictions of our specifications may be employed and exactly as good concrete produced as that made under our present specifications. We have been somewhat inclined to developed a standard specification and have lost sight of the fact that it is not the specification that is to be standard, but rather the product. If concrete posessing the same strength and durability can be made from aggregates having various gradings and limiting sizes then there is no reason to adhere to specifications which confine the selection of aggregates to those of a particular grading and exclude all others.

Until we had before us the results of the investigations of Professor Abrams we could not have said with any precision just what difference should be made in the proportion of aggregates of different sizes in order to produce concrete of a given strength. This we are now able to accomplish; but it is not necessary here to enter into a further discussion of the principles involved. For those who desire to study the matter more thoroughly reference may be made to the bulletins of the Structural Materials Research Laboratory, Lewis Institute, Chicago, particularly Bulletin No. 1.

Under our standard specifications today for fine aggregate we are limited to the use of material varying from ¼-in size particles down to the finer materials, specifying that it shall be reasonably well graded between the smaller and larger particles. Suppose, however, there is available a quantity of sand containing no particles larger than ⅛-in. or possibly containing no particles over 1/14 in., are we to throw away these sands or may we use them, varying the proportions so as to produce the same strength concrete as obtained with the sand containing ¼-in. particles?

Our specifications today for coarse aggregate, while they vary somewhat more than for fine aggregate yet restrict the choice of materials to very narrow limits, the sizes usually specified varying from ¼-in. particles to 2 in., some as high as 3 in. and a number limiting the larger size to 1½ in. But we have at hand, let us say, a large amount of material which contains no particles less than 1 in. in size, varying from that to 2 in. or possibly to 3 in., or there is other material available containing nothing less than ½-in. and perhaps nothing over 1 in. The question is, can we use such aggregates which vary so widely from our present specifications in such a way as to produce concrete as strong and durable as with the aggregates that comply with our present specifications? From the discussion that has been made of Abrams' work we know the answer to be "yes."

Table of Proportions and Quantities.—Professor Abrams has prepared a table which puts the results in a practically available form:

The basis upon which this table has been constructed is the production of a concrete that experience has shown will have sufficient strength and durability for its purpose. There have been many miles of concrete roads built using a 1:2:3 mixture with the fine aggregate varying from ¼-in. size material to the finer particles and the coarse aggregate varying from ¼-in. material to 1½-in. or 2-in. size pieces. Such a concrete tested under laboratory conditions, using 6 by 12-in. cylindrical test specimens and with a plasticity that secures a practical workability gives very closely, at 28 days, a compressive strength of 3,000 lb. per square inch. This was taken as a basis upon which the table has been prepared.

Five different fine aggregates were selected varying as the table will indicate, from the finest which contains no particles over 1/28 in. and others not over 1/14, ⅛, ¼ and ⅜ in. in sizes, respectively. A wide selection of coarse aggregates is given, beginning with the first group which has the smaller limit of size at ¼ in., while the larger limit varies from ¾ in. to 3 in. In the second group the lower limit for the coarse aggregate is ⅜ in. with sizes for the upper limit varying from ¾ to 3 in. Similarly there are groups with the lower limit at ½ in., ¾ in. and 1 in., respectively, the upper limits in each group varying in sizes to 3 in., making in all 27 variously sized coarse aggregates, each in turn combined with five different fine aggregates or sands, thus making 135 combinations of fine and coarse aggregates each of which is proportioned so as to produce under practical working conditions as to consistency the same strength concrete. In all cases it is to be assumed that all aggregates that are to be used, irrespective of size or grading, are to be of material structurally sound, clean and free of organic impurities.

It should be mentioned that Professor Abrams' tests demonstrated that the resistance to abrasion of concretes varied as the compression strength, the greater the strength the greater the resistance to wear; and that concretes of equal crushing strength gave about equal resistance to abrasion.

Practical Application of the Table.—In the practical application of the table we first have to define how to determine what is the upper limit of size for a given aggregate. Should any sand containing a few ¼-in. particles be classed as one varying from zero to ¼ in., or should there be required a certain percentage of material between the ¼-in. size and the next lower limit, as shown in the table which is ⅛ in. The proper allowance, Professor Abrams tells us, should be 15 per cent; that is, a fine aggregate with ¼-in. particles which did not contain 15 per cent by volume of the material passing the sieve with four openings to the inch and retained on a sieve with eight openings to the inch, should be classed as ⅛-in. sand and not as ¼-in.

The following rule is to be applied to determine the limits of sizes for the coarse aggregate: There shall be not less than 10 per cent of material between the largest size and the next smaller size shown in the table. Thus a coarse aggregate to be classed as 2½-in. size shall have not less than 10 per cent of the material between the 2½-in. size and the 2-in. size. If there is less than 10 per cent between the 2½-in. size and the 2-in. size it should be classed as 2 in., providing there should be at least 10 per cent of the material retained upon the 1½-in. screen.

The lower limit of size of a coarse aggregate shall be the largest size shown in the table for coarse aggregate below which there is not to exceed 10 per cent by volume of the material. Thus a coarse aggregate in which the lower limit of size is to be 1 in. should be an aggregate in which there is not to exceed 10 per cent by volume of the material passing the 1-in. screen. In all coarse aggregates if there is to exceed 5 per cent of the volume passing a ¼-in. sieve and such excess shall be considered as fine aggregate and the amount of fine aggregate to be used is to be modified accordingly.

It will be noted that in addition to the proportions by which to combine the various fine and coarse aggregates with the unit quantity of cement there is also given the quantities of the materials to be used to make 1 cu. yd. of concrete. These quantities are given in barrels and hundredths of barrels for cement and in hundredths of cubic yards for the fine and coarse aggregates. The quantities shown do not make any allowance for waste from any source so that for practical estimates they should be increased from the amounts shown as experience in handling the work according to the particular method to be employed has indicated as necessary.

Example of Use of Table.—The following example will make clear the practical use of the table:

It will be supposed that one sand is that usually specified, from ¼-in. down, and must be shipped in at a cost of $2 per cubic yard and that 1 coarse aggregate, varying from ¼-in. to 2 in., must also be shipped in at a total cost of $3 per cubic yard; that there is available locally a supply of sand and coarse aggregate, each being rather fine, the sand varying from ⅛ in. down, which costs $1.50 per cubic yard, while the coarse aggregate varies from ¼-in. to 1 in. and may be secured at a cost of $2.50 per cubic yard. The cement in each case is assumed to cost $3 per barrel. The cost of a cubic yard of concrete using the materials to be shipped in would be as follows:

1.52 bbls. cement, at $3	$4.56
.43 cu. yd. of sand, at $2	.86
.81 cu. yd. of coarse aggregate, at $3	2.43
Total cost of materials for 1 cu. yd. concrete	$7.85
Using local materials the cost would be:	
1.72 bbls. cement, at $3	$5.16
.46 cu. yd. of sand, at $1.50	.69
.66 cu. yd. of coarse aggregate .at $2.50	1.65
Total cost of materials for 1 cu. yd. concrete	$7.50

In this instance the local aggregate, although fine and requiring more cement, will produce a yard of concrete at less cost. In general it will be found that the use of finer sand or of finer aggregate increases the amount of cement, the opposite being true for coarser sizes. Thus a coarse aggregate with all of the fine material removed, varying from 1 in. to 3 in. in size, combined with sand varying from ¼-in. down, uses 1.49 bbls. of cement; whereas an aggregate varying from 1 in. to ¼-in. combined with the same sand, ¼-in. down, requires 1.67 bbl. of cement for a cubic yard of concrete.

If the producer of aggregate materials can say what are the sizes of aggregates he can furnish they can be used to make a concrete of a given strength. Should concrete of a strength other than 3,000 lb. per square inch be desired, then another table would be calculated with the proportions and quantities required accordingly; but the table given here is confined to the use of concrete for concrete roads where a better quality and greater strength are required than is necessary for concrete for many other structures.

Specifications for Proportions Using Abrams' Table.—A specification to include this table would provide a section somewhat as follows:

The proportions of cement, fine and coarse aggregate for the concrete shall vary according to the sizes of the fine and coarse aggregates to be used as indicated in Abrams' Table of Proportions and Quantities as printed herewith. One sack of cement is to be considered as one cubic foot and proportions are to be by volume. The quantity of cement in a cubic yard of concrete in place shall be not less than the amount as shown in the table for a given proportion of coarse and fine aggregates.

Before work is started the contractor shall advise the engineer of the particular sizes of fine and coarse aggregates he expects to use and no change shall be made by the contractor from such sizes except upon due notice in writing to the engineer.

To determine in what classification a given aggregate shall fall the following method shall prevail:

For fine aggregate there shall be not less than 15 per cent of the total volume between the coarsest sizes and the next smaller size shown in the table. Thus, if fine aggregate is to be classed at ¼-in., there shall be not less than 15 per cent of the material between the No. 4 screen and the No. 8 screen.

In coarse aggregate there shall be not less than 10 per cent of material between the largest size and the next smaller size shown in the table. Thus a coarse aggregate to be classed as 2½-in. size shall have not less than 10 per cent of the material between the 2½-in. size and the 2-in. size.

In each instance, where fine or coarse aggregate, if there is not of the coarser sizes the amounts as here described the upper limit of size of the material is to be that of the next smaller size. That is, an aggregate that contains some 2½-in. material, but less than 10 per cent between 2½-in. and 2-in., is to be classed as 2-in. size for the upper limit.

The lower limit of size of a coarse aggregate shall be the size shown in the table for coarse aggregate below which there is not to exceed 10 per cent of volume of the material.

If there is to exceed 5 per cent of the volume of coarse aggregate passing the No. 4 screen then such excess shall be considered as fine aggregate and the amount of fine aggregate to be used shall be modified accordingly.

Aggregate falling between limits of sizes other than shown by the table may be used only upon special written permission of the engineer and in such proportions as he may indicate.

In all cases aggregates both fine and coarse are presumed to be reasonably well graded between the limits specified.

Specifications for Consistency.—The amount of water to be used for mixing concrete shall be that which will give a consistency to be determined as follows:

Newly mixed concrete shall be placed in a truncated cone-shaped metal mold having an 8-in. base, 4-in. top and 12-in. high. The concrete shall be lightly tamped with a rod as it is placed in the mold, which when filled is to be immediately removed by means of handles on either side of the mold and the slump or settlement of the concrete noted. For concrete to be finished by a mechanical tamping machine the slump shall not be less than ½-in. nor to exceed 1 in. If the concrete is to be finished by hand methods the slump may be as much as 1½ in.

Rapid Construction of Asphaltic Concrete Pavement

An average rate of 2 miles per month was made last year in the construction of an asphaltic concrete pavement on the Gratiot Road in Michigan. The best record was 1 mile in 8 days. The contract was let in February, 1919. It provided for a highway 24 ft. wide, paved with asphaltic concrete on a portland cement concrete base. The road extends from the southern limit of the city of Mt. Clemens through Clinton, Erin and Warren Townships in Macomb County, covering 10.25 miles and connecting Detroit with the Shore Line leading into the "Thumb of Michigan." A 6-in. concrete base with curbs integral was provided for the first 3.4 miles; the remainder has a 7-in. concrete base. An asphaltic concrete top of Native Lake Asphalt, 1½ in. in thickness, was laid on a 1½-in. binder course. The specifications called for this thickness after rolling. Two locomotive cranes at loading points enabled the contractor with his other mechanical equipment to carry on the work without delay. The fast time made on the job was in a large measure due to continuous and systematic delivery of materials. The Detroit Asphalt Paving Co. of Detroit was the contractor, and the work was carried on under the supervision of the County Road Commissioners of Macomb County and Walter J. Lehner, County Engineer.

Mileage and Cost of Road Construction in Iowa.—The cost of constructing roads to permanent grade in Iowa last year was over 100 per cent greater than it was in 1917, according to figures in the February-March Service Bulletin of the Iowa Highway Commission. The following table, compiled from the bulletin, and based on county engineers' reports, gives comparative figures on various classes of road construction:

	1917.		1918.		1919.	
	Miles.	Average cost per mile.	Miles.	Average cost per mile.	Miles.	Average cost per mile.
Roads constructed to permanent grade	380	$1,048	508	$1,633	445	$2,533
Roads constructed to temporary grade	41	1,733	29	1,770	35	2,198
Roads constructed to natural grade	2,491	154	2,185	154	1,370	212
Roads surfaced with gravel	408	1,108	335	1,093	329	1,758
Roads paved		...	7.9	31,822	4.1	41,756

Are College Graduates Too Humble?

By P. B. McDONALD.

Assistant Professor of English, College of Engineering, New York University.

A business man of Dayton, Ohio, Mr. Houston Lowe, has been quoted in the American Magazine as saying that college graduates do not make good salesmen because they have "too much humility." This gentleman affirmed that the college man has been trained to allow other men to decide his affairs for him; that he looks at a matter from too many angles; and that he does not argue a hesitating customer into accepting the particular product for sale.

Discounting somewhat this business man's probable prejudice for "gingery" sales arguments and his tolerance for cheap persuasion in getting a customer to buy something that he does not want, there remains a modicum of truth in what he said. The college-bred man is likely to lack imagination and intellectual initiative. Mr. J. E. Spurr, editor of the "Engineering & Mining Journal," in his recent address to the students of the Michigan College of Mines, expressed it thus: "The handicap of the college-bred man is a lack of initiative and a too great fear of doing this or that which is below his dignity."

"Mr. Dooley," that inimitable American humorist, has explained the great fault of American university education by giving an account of a conversation between a college president and a father who plans to send his boy to college. Mr. Dooley has the president ask the father in what field of learning he wishes the professorial specialists do the lad's thinking for him!

But to have the college man go to the other extreme would be equally as bad. In fact, some graduates are quite the opposite from humble. An unfriendly observer has expressed it: "You can always tell a Harvard man, but you can't tell him much." The proper point of view can not be learned glibly; the right balance is one requiring sound personal conviction. John Galsworthy has said that the best ideal is poise or balance, and that the greatest concern of a nation should be education, taking the term in the broad sense.

College graduates today, and engineering graduates in particular, have not thought themselves into the proper philosophic point of view. As G. K. Chesterton has pointed out, the most important thing about a young man, even today when life is so highly specialized, is his attitude toward the world. Cynical educators may say: "All very nice, but how are you going to induce the undergraduate to think himself into the proper philosophic attitude?" The answer is, by putting the student under the guidance of professors who can instill and develop the right philosophic view of life while teaching mathematics, engineering, science, etc. There are certainly enough courses taught in college without adding "point of view" or engineering philosophy, and when students are lectured to in such a separate course they are likely to think that what they learn there is to be discarded as soon as they leave the class-room.

Milo S. Ketchum has observed, from his long experience in engineering education, that the cultural value of a course depends more on the teacher than on the subject, and he suggests that the greatest need is for better teachers. President Hadley of Yale has said that the great difficulty in higher education is finding teachers who have the right combination of views on learning and on life. But cynical educators may still "agree that the crux lies in the need for better teachers, but how are they to be obtaiend?" That is the point; university deans and college presidents "regret" (in general statements) the scarcity of good teachers, but they are disinclined to hire a professor for his teaching ability. They cling to the medieval tradition of judging a man's fitness to teach by his string of degrees and his academic honors gained through committee routine or hair-splitting research. They consider that a professor who has written a book that nobody has read, or who has sat complacently on committees of adjusting clerical details, is best fitted to inculcate in young men the right philosophy that will make him a leader in the life of today. That is, educators bemoan the lack of better, broader teachers—and continue to engage the conventional narrow specialist. If a new type of professor is suggested to them, they retreat into academic conservatism and fail to understand how such a change can be made.

If the college graduate lacks initiative, and the ability to adjust himself to changing conditions, part of the cause lies in the medieval prejudices that exclude initiative and adjustment in the teaching staffs of the universities. Although, to a certain degree, the university should remain (as President Meiklejohn of Amherst recommends) a place for dreamers an oasis of detached, abstract thinking—it should display some imagination and intuition in attracting teachers who are themselves living literature and making history, rather than merely classifying details and covering books with cobwebs. If young men are taught for four years by teachers who cling to tradition, and lack initiative and imagination, is it any wonder that college graduates are being severely criticised? This does not mean that the colleges should pursue fads and take up with the ephemeral movements that float along; the college, above all, should emphasize the real and true things that civilization has proved. But there is such a thing as applying the universal truths that man has found to the life of the day.

The college man should do for the present what Socrates did for his period. As Professor Frank Thilly says in his history of philosophy, men were "needed to bring order into the intellectual and moral chaos of the age, to sift the true from the false, the essential from the accidental, to set men right and to help them to see things in their right relations." Men to do this must have initiative and the ability to apply universal principles to the shifting affairs of the day. If college men are to be trained to serve the nation in this manner, a different type of teacher must be set over them. Educators can not improve their faculties by uttering generalities about the need for better teachers, while continuing to employ the same types of sitters on committees and narrow specialists as in the past.

Storage Pile of Sand and Gravel and Cement Shed.

Fellowships in Highway Engineering and Transport at University of Michigan.—The Department of Civil Engineering of the University of Michigan announces that the following fellowships are available during the collegiate year 1920-1921. The Roy D. Chapin Fellowship in Highway Transport. This fellowship is offered to provide for the investigation of an approved subject relative to highway transport. It pays the sum of $250 with an allowance of $50 for expenses. The Roy D. Chapin Fellowship in Highway Engineering: This fellowship is offered to provide for the investigation of an approved subject relative to hard surfaced roads and pavements. It pays the sum of $250 with an allowance of $50 for expenses. Two Detroit Edison Fellowships in Highway Engineering: These fellowships are offered for the investigation of approved subjects relative to moderate cost country roads. Each fellowship pays the sum of $250 with an allowance of $50 for expenses. A Fellow must hold a bachelor's degree from a college of recognized standing. He must enroll as a candidate for the degree of master of science or master of science in engineering and be in residence for one of the following periods: First, semester (October to February); winter period (December to March); second semester (February to June). An application for a fellowship must include a concise statement of the candidate's educational training and his activities since he received the bachelor's degree. Applications should be sent to Arthur H. Blanchard, Professor of Highway Engineering, University of Michigan, Ann Arbor, Michigan, not later than Sept. 1, 1920.

Construction Methods and Equipment on Lincoln Highway Job in Whiteside County, Illinois

An interesting feature of last season's work on a 13-mile section of the Lincoln Highway in Whiteside County, Illinois, was the varied use made of light tractors.

The contract consisted of a 16-ft. concrete pavement, 8 in. thick in the center and 7 in. at the edges, with a 7-ft. earth shoulder on each side and numerous small plain and reinforced concrete culverts and two reinforced concrete bridges.

The rough grading ran about 3,000 yd. per mile with an average haul of 300 to 400 ft. The greater part of the grading was done with wheel scrapers. During the early part of the season good teams were hard to find so four light tractors were purchased. One tractor on the plow and three on short-tongued wheelers made a good workable gang. A gang of eight teams was also maintained and the work of the two gangs compared. It was difficult to get men to drive the teams while there was no trouble to get men to drive the tractors. The greatest trouble with the tractors was to get the drivers to take care of them. The foreman required each driver to go over his machine every 2½ hours, check over everything and fill with gas, oil and water if needed.

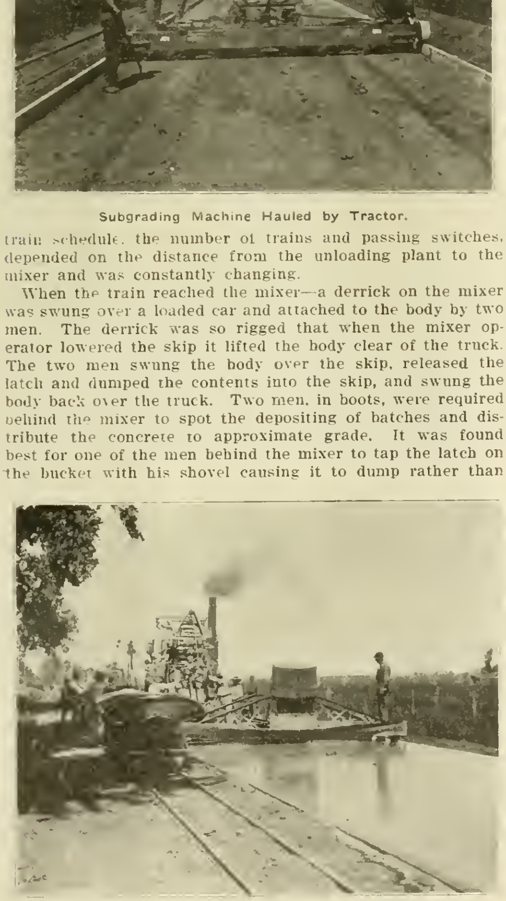
The tractor gang accomplished about the same amount of work as the team gang until the extremely dry weather in August, when the tractors, after a few trips on a wheeler run raised such a cloud of dust that the drivers could not stand it. The tractor gang was then discontinued and the tractors used on the sub-grading gangs. The rough grade was built two to three-tenths above sub-grade from shoulder to shoulder so that after settling there was zero to two-tenths to be removed from the 16 ft. where the pavement was to be placed. A blade grader drawn by a tractor or roller removed this earth to approximate grade and pushed it to the shoulder. The steel side forms were then set to proper grade and alignment and the sub-grader traveling on the side forms, and adjusted to ¼ to ½ in. above sub-grade, was pulled over, thus bringing the sub-grade to a uniform plane surface. It was then thoroughly rolled and the sub-grader again pulled over, this time adjusted to exact sub-grade. Any excess earth was windrowed by the sub-grader and thrown to the shoulders with shovels. During the dry part of the season it was found best to thoroughly wet the sub-grade ahead of the sub-grader so that it would shave the surface smooth and not break it out in chunks.

A type A-1 Thew shovel with 35 ft. boom and ¾-yd. clam shell bucket unloaded the sand and gravel from gondolas on to a tunnel, set on the surface of the ground parallel to the unloading track. The hauling of material was done with a 24-in. gage Lakewood industrial railroad. The track was laid on the shoulder 3½ ft. from edge to pavement to center of track. The rolling stock consisted of 3-ton Plymouth locomotives and 20 cu. ft. cars. The car bodies were divided into three compartments, the divisions being so spaced that when filled the body will contain the proper proportions for a batch of concrete. Each locomotive pulled 10 to 15 cars, depending on the grades, at an average speed of 8 miles per hour.

A train was pulled into one end of the tunnel and the gravel which has been stored above the tunnel was dumped by gravity through traps so spaced in the roof of the tunnel that the entire train could be loaded at one set. The train was then loaded with sand in the same manner, then pulled to the cement house or platform and loaded with cement. The train schedule, the number of trains and passing switches, depended on the distance from the unloading plant to the mixer and was constantly changing.

Subgrading Machine Hauled by Tractor.

When the train reached the mixer—a derrick on the mixer was swung over a loaded car and attached to the body by two men. The derrick was so rigged that when the mixer operator lowered the skip it lifted the body clear of the truck. The two men swung the body over the skip, released the latch and dumped the contents into the skip, and swung the body back over the truck. Two men, in boots, were required behind the mixer to spot the depositing of batches and distribute the concrete to approximate grade. It was found best for one of the men behind the mixer to tap the latch on the bucket with his shovel causing it to dump rather than allow it to dump automatically as he knew better where he wanted the batch than did the mixer operator.


Industrial Equipment and Finishing Machine.

The ponding method of curing was used on all pavement of less than 2 per cent grade A dyke 18 in. wide at the base and 8 in. high was thrown on each edge of the pavement with a cut-off dyke every 10 to 60 ft., depending on the grade. The ponds were kept full of water for two weeks. On grades above 2 per cent and on super-elevations as well as around corners the pavement was covered with 2 in. of earth and kept moist for 14 days. The covered pavement required less water but took a great deal longer to apply it as one man could handle only one hose whereas one man could handle two or three hose in filling ponds. The diking cost only about half as much as covering.

Water was supplied by double unit triplex pumps driven by kerosene engines, all mounted on a truck. Each unit was capable of delivering 40 gal. per minute at a pressure 225 lb. at the pump. The pumps were fitted with adjustable relief valves. The pumps were run continuously from morning until night and any excess water in the line caused by stopping the mixers, etc., was wasted through the relief valves. A 2-in. pipe line was used with T's every 150 ft. and cut-off valves at various places. A 1-in. hose connected the pipe line to the mixer. The mixers were never held up for lack of water. The greatest distances from the water supply was 2¼ miles. The contractors for this section were the J. J. Dunnegan Construction Co. J. R. McDaniel was the superintendent in charge for the contractors.

Charging Mixer.

Conference to Organize Representative Engineering Body.—The Joint Conference Committee of the American Society of Civil Engineers, American Institute of Mining and Metallurgical Engineers, American Society of Mechanical Engineers and American Institute of Electrical Engineers, has issued a call to the engineering organizations of the United States for an organizing conference to be held at Washington, D. C., June 3 and 4. A plan of organization has been forwarded by the Joint Conference Committee upon the following principles:

1. Non-interference with the interrelations with respect to technical matters, and the maintenance of the autonomy, functions and operations of individual organizations.
2. Local affiliation of existing groups of engineers in order to facilitate united action in local questions of public welfare and other matters of common interest.
3. National association of engineering organizations by means of a national council composed of representatives widely chosen by local affiliations or organizations and by national organizations, meeting annually and acting through an executive board.
4. Financial support of such association by contributions from all participating organizations on a basis of membership.
5. A form of organization which will permit expansion and development.

The Joint Conference Committee is endeavoring to incorporate these principles in the form of a constitution and bylaws, which will be subsequently presented.

Convention of American Society for Municipal Improvements.—The time and place of the next convention of the American Society for Municipal Improvements have been fixed for October 12-15, 1920, at the Planters' Hotel, St. Louis, Mo. C. C. Brown, Valparaiso, Ind., is secretary.

Notes on Street Paving for Smaller Minnesota Cities*

By GEORGE M. SHEPARD.
Associate with Louis P. Wolff, Consulting Engineer, St. Paul, Minn.

As a general rule, in cities of less than 10,000 inhabitants, where no paving has been done and no fixed policy determined, bids are called for upon several types of pavement, and the final selection is made upon a basis of cost and engineering advice as to adaptability for existing conditions. It is therefore common practice for engineers in this part of the country to prepare specifications covering various types of pavements rather than to restrict the bids to a single type.

I will give a few notes covering pavements actually constructed during 1919, under specifications drawn by this office, or contracted for during the present year, up to the present time. Out of a total of 575,000 sq. yd. of pavements contracted for between March 20, 1919, and Feb. 17, 1920, covering 10 cities of this class, 255,000 sq. yd. were reinforced concrete, 45,000 sq. yd. were asphaltic concrete, Class A, and 275,000 sq. yd. were asphalitic concrete, Class B.

Roadway Crowns and Gutter Slopes.—The first matter of importance for the engineer to determine is the width of the roadway on the streets. For a main street, 100 ft. in width between property lines, 15-ft. walks, with a 70-ft. roadway, works out very well; while for an 80-ft. street, 12-ft. walks and 56-ft. roadways give suitable proportions. Under conditions generally found in cities of this class the walk width on each side of a business street should be approximately 15 per cent of the entire width of the street.

For residence streets a minimum width of paving of 30 ft. has been adopted, with 34 to 40 ft. for the arterial streets connecting with state highways in the country. The paved roadways of semi-business streets may vary between the above limits. Where extremely wide streets occur in the residence districts, double roadways are frequently used, with a parkway at the center.

The pavement crowns vary with the type of pavement and the grade of the street. For concrete pavements the crowns vary from 0.5 ft. for a 30-ft. width to 0.75 ft. for a 70-ft. width. For asphaltic concrete pavements the crown varies from 0.55 ft. for a 30-ft. width to 0.85 ft. for a 70-ft. width. For steep grades the crown is somewhat less than the figures just given.

Experience has shown that where the gutter slope is less than 0.8 ft. per block of 300 ft. the drainage is unsatisfactory, consequently with flat grades the normal curb exposure of 6 in. is varied to obtain the necessary fall.

Sub-Drainage.—The matter of sub-drainage is as important with city pavements as with country roads, and in some places it is common practice to lay tile drains adjacent to the curbs. However, in cities where both storm and sanitary sewers have been previously laid, there is a question as to the advisability of incurring additional expense for tile drainage, as the existing sewers will be quite effective in draining the soil, especially after the pavements are completed and proper surface drainage has been provided.

In a strictly business district the entire area is covered with buildings, pavements or sidewalks, leaving very little access to the tile for surface water, and in a residence district with properly sloped boulevards, surface water quickly finds its way to the pavement, gutters, and thence into the storm sewers.

There is also the additional subsoil drainage obtained by sewer trenches and house connection ditches. Nearly all engineers are familiar with the lowering of ground water level which takes place after the construction of a sewerage system, most of this lowering being due to indirect entrance to the sewer system through pipe joints. Although there are cases in heavy soil where tile drainage for city pavements is beneficial, in many instances it is an unnecessary expenditure.

Grading.—The grading includes the making of fills, the removal of all material between curb lines, the preparation and rolling of the sub-grade ready for the laying of the pavement proper, together with removal of all crossings, gutters and walks.

Excavation is paid for on a cubic yard basis, the price bid including all of the above items. Excess material not placed behind the curbs or used for filling boulevards is hauled away, overhaul being paid for at the rate 2 ct. per cubic yard per 100 ft., over a free haul of 1,000 ft.

The sub-grade is brought to a firm, unyielding surface by rolling with a 10-ton roller. By using a roller of this weight, soft spots in the streets, due to new and old ditches, are compacted and danger from future settlement avoided. Where fills are made all vegetable or perishable matter is removed from the top surface, the fill deposited in layers not more than 12 in. in thickness, and the surface passed over at least twice with the roller.

Curbs.—Alternate bids are generally received upon two or more types of curbs. Type A is a standard curb, 6 in. wide and 17 in. deep. Type B is a special curb generally used in the business section and on filled streets. It is 6 in. thick at the top, with a 1:12 batter on the front face, and a depth varying with conditions. Type C curb is a 6-in. integral curb which is used only in connection with reinforced concrete pavements. Type D curb is a combined curb and gutter, consisting of a 6-in. curb with a 2-ft. gutter apron. This latter type is used more particularly with pavements having an asphaltic wearing surface, and its use is confined principally to residence districts.

The mixture specified for curbs is a 1:2½:4½ mix, using approved crushed rock or screened gravel for coarse aggregate, or a suitable mixture of pit-run gravel, based upon the proportions given in the following table:

PROPORTIONS FOR PIT-RUN GRAVEL.

Ratio pebbles retained on No. 8 to pit-run.	Use		Use		
	Sacks cement.	Cu. ft. pit-run gravel.	Sacks cement.	Cu. ft. pit-run gravel.	Cu. ft. screened gravel.
.66	1	5.00	1	5.00	0.00
.60	1	4.65	1	4.65	0.14
.55	1	4.39	1	4.39	0.76
.50	1	4.16	1	4.16	1.05
.45	1	3.94	1	3.94	1.33
.40	1	3.75	1	3.75	1.56
.35	1	3.57	1	3.57	1.79
.30	1	3.41	1	3.41	1.99
.25	1	3.27	1	3.27	2.16

After the concrete has been poured and has stiffened sufficiently, the forms are removed and the top surface and exposed face troweled to a smooth and uniform surface. The surface of the gutter for the Type D curb is finished with a 1:2 Portland cement mortar ½ in. in thickness, which is put on immediately after the concrete has been placed.

Expansion joints ⅜ in. wide, extending through the entire thickness of the curb, are placed in the curbs in line with the transverse expansion joints in the concrete pavements and at intervals of about 30 ft. for other pavements. Radius curbs varying from 2 ft. radii at alley returns on business streets to 15 ft. or 20 ft. radii at residence street intersections, are used.

Reinforced Concrete Pavements.—Reinforced concrete pavements both 6 and 7 in. in thickness have been constructed, the thickness depending upon the soil and traffic conditions. The cement used is required to meet the latest specifications and tests for portland cement adopted by the American Society for Testing Materials. The contractor provides for inspection at the mills by a reliable testing bureau, and includes the cost in his bid, this bureau furnishing certified copies of the mill tests of each shipment to the engineer.

The fine aggregate is clean, hard sand, free from clay, loam or other deleterious matter, and when tested by laboratory screens must meet the following requirements:

	Per cent
Passing a ¼-in. screen	100
Passing a 20-mesh and retained on the 50-mesh sieve	30 to 65
Total passing 50-mesh sieve, not more than	20
Total passing 100-mesh sieve, not more than	5

Alternate bids were formerly received, based upon using crushed granite, trap rock or quartzite or screened gravel, but recently the bids have covered the following three classes of coarse aggregate: First, Class A rock, consisting of the best quality of crushed granite, trap rock or quartzite, having a French co-efficient of wear of not less than 8 and a toughness of not less than 8; second, Class B rock, consisting of crushed rock, having a French co-efficient of wear of not less than 5 and a toughness of not less than 5, and third, consisting of clean, screened gravel.

The inclusion of the Class B rock was due to the fact that on account of the scarcity of the harder materials, the paving construction would have been cut down considerably had not more available and somewhat softer rocks been allowed.

The concrete for reinforced concrete pavements is a 1:2:3½ mix containing not less than 1.7 bbl. of cement per cubic yard of concrete for hand finish, or a 1:2:4 mix, containing not less than 1.6 bbl. of cement for machine finish.

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*[illegible] paper presented at the 1920 annual meeting of the Minnesota Surveyors' and Engineers' Society.

It is required that each batch remain in the mixer at least 1 minute after all materials have been placed in the drum, and shall have not less than 12 nor more than 18 full turns of the mixing drum.

Although machine-finishing is covered by several clauses in our specification, machines have not as yet been developed for suitable finishing of pavement over 24 or 26 ft. in width and consequently are not as yet in use for finishing city pavements, although they are very commonly employed on county highways.

In hand-finishing, the surface of the concrete is struck off by means of a strike board or is brought to the proper surface by means of grade-pins and floats manipulated by wooden handles. Special care is taken to consolidate the concrete along expansion joints. After the surface is brought to proper grade it is rolled with a split roller aproximately 10 in. in diameter and 6 ft. long, weighing about 75 lb. At expansion joints the split is opened and the roller operated so that the split will straddle the joint. This operation is to be repeated at intervals of 15 to 20 minutes until no free water is squeezed from the surface. Immediately after the rolling the surface of the pavement is finished with belts, the surface being gone over twice.

The space along the curb which cannot be finished with a belt is finished with a wooden float. A separate float is used to finish the surface along expansion joints and to better compact the concrete at this place a finish tool is used to finish the edges of the joints to a ¼-in. radius.

After the concrete is sufficiently hardened, the surface of the concrete is kept continuously moistened by sprinkling, and under most favorable conditions the pavement is not opened to traffic for at least 14 days after its completion. Concrete is not mixed or deposited when the temperature is below freezing.

Longitudinal expansion joints are constructed along each curb and also at intermediate points for streets over 55 to 60 ft. in width. Transverse expansion joints are constructed across the pavements at intervals generally not less than 40 ft., and at street intersections running diagonally from the radius curbs towards the center of the street.

The diagonal joints at the intersections are used to eliminate the unsightly cracks which generally radiate from manhole covers at the center of streets where joints and reinforcement have not been used.

All joints are formed during construction by inserting and leaving in place a joint filler, ⅜ or ½ in. in thickness, extending through the entire thickness of the paving.

No metal protection at the joints is used, but especial care is taken to secure a dense concrete and a true surface next to the joint. The principal objection to joints is the slight impact at regular intervals felt when riding over a pavement with expansion joints, this usually being due, not to the joint material, but to the improper finishing of the surface on either side.

The concrete pavements are reinforced with round, deformed bars, of structural or intermediate grade steel, the total weight of steel being approximately 3 lb. per square yard. Each separate block between expansion joints is generally reinforced along all edges, with a ⅝-in. round bar laid about 6 in. from the edge, and through the interior with ½-in. round bars. The bars are placed so that the center shall be 2 in. below the top of the finished pavement.

Concrete Base.—The tendency in Minnesota has been toward the construction of a rigid base for all pavements with wearing surface. The rigid base has the advantage of bridging over any soft spots in the sub-grade, and is suitable to the extreme climatic changes which occur in this region.

In our work in cities of this class a Portland cement concrete base 5 or 6 in. thick has been specified, alternate bids being received upon the two thicknesses. Crushed rock or screened gravel is used for the coarse aggregate of the base, a 1:2½:4 mix being used for hand-finished and a 1:2½:4½ for machine-finished work.

In order to insure the proper compactness of the concrete in the base, rolling similar to that employed for concrete pavements is required, after which the surface must be gone over with a spiked roller or tamper, so as to provide a proper bond for the wearing surface.

Asphaltic Concrete, Class A.—This pavement consists of an asphaltic concrete wearing surface 2 in. thick, laid upon a 5 or 6-in. concrete base. Natural lake fluxed asphalt or oil asphalt meeting the specified requirements may be used for the bituminous cement. The penetration required for the fluxed natural lake asphalt or the oil asphalt at 77° F. is 55 to 60 for 100 gr. wgt. 5 sec.

The coarse aggregate consists of best quality crushed granite, trap-rock or quartzite, having a French co-efficient of not less than 8 and a toughness of not less than 8. When tested by laboratory screens it must meet the following requirements:

	Per cent.
Passing ½-in. screen, not less than	95
Retained on ¼-in. screen, not less than	37
Retained on 10-mesh sieve, not less than	100

The fine aggregate is composed of sound, durable stone particles or of clean, moderately sharp sand, properly graded. When tested by means of laboratory screens the fine aggregate shall meet the following requirements:

	Per cent.
Passing a ¼-in. screen	100
Passing a ⅛-in. screen	95
Retained on 200-mesh sieve, not less than	95

The mineral filler consists of portland cement and limestone or dolomite dust. Not less than one-half of the mineral filler is portland cement and not less than 47 lb. of portland cement is used in each 1,000-lb. batch of bituminous concrete.

The total mineral aggregate must consist of a uniform mixture of the above ingredients, the grading and proportionate amounts of each being such as to give the following proportions:

	Allowable limits. %	Desired. %
Passing 200 mesh	10 -12	11
Passing 80 mesh	10½-12½	11½
Passing 40 mesh	10 -14	12
Passing 20 mesh	11½-15½	13½
Passing 8 mesh	13 -17	15
Passing ¼-in. screen	13 -19	16
Passing ½-in. screen	18 -24	21
		100%

After being thoroughly heated to the temperature directed, the bituminous material and the mineral aggregate is measured and mixed so that the resulting mixture contains from 70 to 90 lb. of the bituminous cement to 1,000 lb. of mineral aggregate. When delivered, the bituminous concrete must have a temperature of not less than 225° F.

The mixture is dumped far enough in advance of its final position to insure the load being turned. When rolled and thoroughly compacted it must have a thickness at no place of less than 2 in. and a weight per square yard of not less than 220 lb. for each batch, and must be free from surface depressions or irregularities.

Upon completion of rolling, a thin coat of Portland cement is applied with a broom, using 1 bbl. of cement to 1,200 sq. yd. of pavement.

Asphaltic Concrete, Class B.—As with Class A, this type provides for a 2-in. wearing surface of asphaltic concrete, laid upon a 5 or 6-in. concrete base. The specifications and requirements for bituminous cement are the same as described for Class A.

The broken stone is of the best quality of crushed granite, trap-rock or quartzite, having a co-efficient of wear of not less than 8 and a toughness of not less than 8. The coarse aggregate must be the product of the crusher, which, when tested by means of laboratory screens, must meet the following requirements:

	Per cent.
Passing a 1-in. screen, not less than	95
Total passing a ¾-in. screen	35 to 65
Retained on ¼-in. screen, not less than	95

The fine aggregate is composed of sound, durable stone particles or a clean, moderately sharp sand, and, when tested by means of laboratory screens, must meet the following requirements:

	Per cent.
Passing ¼-in. screen	100
Total passing ⅛-in. screen	95
Total passing 40-mesh sieve	30 to 70
Retained on 200-mesh sieve, not less than	95

The mineral filler must consist of limestone dust, dolomite dust or Portland cement. The total mineral aggregate must consist of such a mixture of the coarse and fine aggregate that, when tested by means of laboratory screen, it will conform as closely as possible by weight to the desired proportions as given in the following table:

	Allowable limits. %.	Desired. %.
Passing 200 mesh	7 - 9	8
Passing 80 mesh	6 - 8	7
Passing 40 mesh	6 - 8	7
Passing 20 mesh	6 - 8	7
Passing 8 mesh	6½ - 9½	8
Passing ¼-in. screen	6½ - 9½	8
Passing ½-in. screen	14 - 20	17
Passing 1¼-in. screen	34 - 42	38
		100

From 70 to 90 lb. of bituminous cement for each 1,000-lb. batch of mineral aggregate is required. This mixture is spread and rolled as previously described, so that after rolling it has a thickness at no place of less than 2 in., and a weight of at least 240 lb. per square yard for each batch.

As soon as possible after the rolling of the mixture has been completed, and while the surface is still warm and clean, a seal coat of asphaltic cement is spread over the surface, sufficient in amount to fill the surface voids. Over this seal coat is spread a dressing of clean stone chips, this covering to be broomed and rolled into the surface, a small surplus being left to wear away by traffic.

Creosote Wood Block Pavement.—Previous to the war a number of the smaller cities had laid several blocks of creosoted wood block pavement in the business districts, where subject to the heaviest traffic, and there has generally been a tendency to consider this type when bids have been received since the war. This pavement, as specified, consists of a creosote wood block laid upon a pitch filler on a concrete base, alternate bids being called for, using 3 and 3½-in. blocks. On account of the high prices bid for this type of pavement, however, very little has been constructed during the past year outside of the larger cities.

Bids have been asked for upon other types than those which have been herein described, but on account of the high cost during the past two years, and because the cities of this class in this region are in the early stages of pavement construction, the types generally bid upon are those of simple construction and of lower cost. Decreasing cost and growth of paving construction will see the use of other types. The contracts let for paving, grading and curbs up to date this season have averaged approximately 35 per cent higher than those contracted for during the season of 1919. The reasons assigned by contractors for this increase in price are: first, increase in cost of materials; second, higher labor cost; third, transportation shortages and delays, and, fourth, general uncertainty of industrial conditions.

Road Construction in Quebec in 1919.—From July 1, 1912, to Nov. 27, 1919, a total of $23,694,000 was spent for the general improvement of roads in the Province of Quebec. This work was done under the Quebec government act of 1912. The roads built during the season of 1919 were:

	Miles.
Gravel roads	341.77
Waterbound macadam	93.94
Bituminous macadam (penetration)	5.87
Bituminous concrete	3.07
Concrete	6.75
Total	451.40

The total mileage of trunk roads in the Province is over 350, and the government has now under consideration for the future an approximate total mileage of 1,700 miles. The total mileage of all the rural roads of the Province under the municipal control and outside of the cities is about 40,000 miles. Of this total 3,008.38 miles are improved with either gravel, water-bound bituminous bound macadam, asphaltic or cement concrete.

Engineering Cost on Iowa Road Work.—The following table from the February-March Service Bulletin of the Iowa Highway Commission shows the percentage of engineering costs for road work in that state:

	1914.	1915.	1916.	1917.	1918.	1919.
County engineering	2.85	2.75	2.53	2.58	3.19	2.78
Highway Commission	.64	.60	.63	.59	.78	.75
Total all engineering	3.49	3.35	3.16	3.17	3.97	3.53

Minneapolis Method of Finishing Concrete Base for Wood Block Pavement.—In constructing creosoted wood block pavement the paving department of Minneapolis, Minn., obtains an even surface on the concrete base by means of a 3-in. pipe about 15 ft. long filled with sand. This is operated on wooden templets, the top of which is at grade of the surface of pavement. This method gives an even surface and gets its rapidly and cheaply.

Road Construction in Illinois During 1919

By B. H. PIEPMEIER,

Engineer of Construction, Division of Highways.

During 1919 there were 685.39 miles of Federal Aid and State Aid roads placed under contract by the Division of Highways of the Illinois Department of Public Works and Building. In addition there were 6.44 miles of roads carried over from 1917 and 1918, making a total of 691.83 miles placed under construction in 1919.

There were completed during 1918, 247.24 miles or 36 per cent of all work. The accompanying charts clearly show when the work was placed under contract and the construction progress. A careful study of the charts show that a great many more miles could have been completed had the work been placed under contract at an earlier date. There were several other outstanding causes that delayed the work. It will be noted that the maximum mileage per week was not reached until the month of October. This delay in reaching the maximum output per week was caused by the inability of the contractors to secure road equipment. Many of the contractors were delayed from 3 to 4 months in getting proper machinery. Delays on account of machinery repairs were also very serious. The next most serious cause for delay was shortage of material. Much of the equipment was working but one-half of the time on account of material shortage. Labor shortage and labor strikes in various divisions of work seriously delayed the delivery of materials and the progress of the work. About the time that the maximum amount of work per week was reached it was suddenly stopped by winter weather. Had the construction season

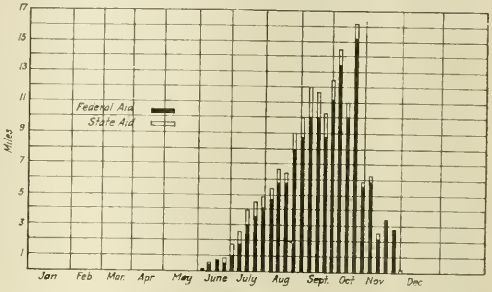


Chart Showing When Illinois Road Contracts Were Let.
Pavement (Federal Aid), 535.4 miles, earth 34.71
Pavement (State Aid) 38.22 miles, earth 75.89

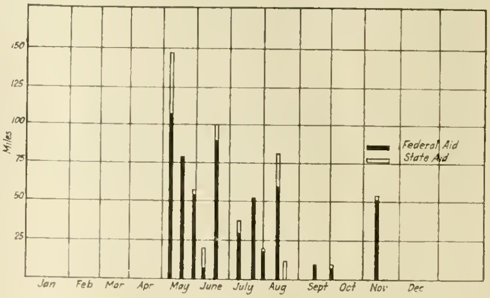


Chart Showing Mileage Constructed Each Week During 1919 Construction Season.
Paved (Federal Aid), 147.42, earth 22.75
Paved (State Aid), 34.68, earth 54.04

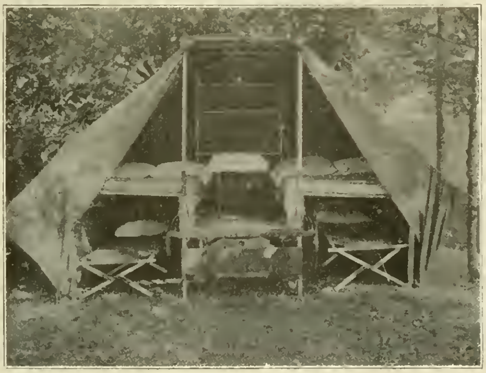
been two months longer fully 100 per cent more work could have been finished.

The slow progress of the work in 1919 could in no way be charged against the contractors. They as a rule exerted every possible effort to execute their work, but it seemed that very change in conditons resulted in a disadvantage to the contractors. In many instances the contractors who exerted the most effort or tried to produce the greatest mileage, got the least results.

On account of the unfavorable conditions existing during 1919 the contractor who organized and planned to do a large volume of work produced much less in proportion to their investments and efforts than the man that operated the smaller unit. It was almost impossible to work the larger units to their capacity on account of the shortage of labor and material. The smaller units were worked to their capacity a very large part of their time, hence proved to be more economical. The larger units have their many advantages and under normal conditions will undoubtedly prove their economy.

Trailer Camp Outfit for Road Maintenance Gang

Comfortable sleeping quarters for members of the surface treating gangs of the maintenance and repair bureau of the Ohio State Highway Department are provided by a compact 2-wheeled folding camp trailer. The surface treating outfits have been motorized as far as possible to expedite the work and to reduce to a minimum the time lost by moving between jobs. Each distributor superintendent is supplied with a Ford touring car so that he can easily keep in touch with all parts of the work from the railroad station to the road being treated and go ahead to make advance arrangements for his next job. While moving between jobs the camp trailer is attached to the superintendent's touring car. A separate cook tent and stove are also supplied which make a very complete camping equipment for the men. As all work done by these outfits is outside of municipalities and is limited to the summer months, these camping outfits have been popular with the men and it has been less expensive for the State than paying for their board and room.



Folding Camp Outfit on 2-Wheel Trailer.

Depreciation in Highway Construction Plant.—Where a plant is assumed to have a life of five years, a great many contractors are charging off 20 per cent yearly. A more correct way, states Mr. Richard Hopkins in a paper presented at the recent convention of the American Road Builders' Association, is to charge off about 40 per cent the first year, 40 per cent of the remainder the second year, 40 per cent of the remainder the third year, and so on until the end of the 5-year period.

Tree Planting and Camp Sites Along State Highways.—Roadside Tree Planting is advocated by the State Highway Commission of California in its 1919 report. The commission has planted trees in a 17-mile sector across a desert and has purchased pipe for a 10-inch water supply line for the trees. The purchase of camp sites along highways also is advocated.

Cost of Unloading Broken Stone from Cars by Hand Shoveling

In a paper presented at the sixth annual conference of County Road Superintendents and Engineers of Ontario Mr. A. M. Jackson, Engineer of Brant county, Ontario, states that in 1919, with wages at 40 ct. per hour, the cost of unloading broken stone by hand amounted to 20 ct. per ton, when the material was shoveled out of flat-bottom cars with about 3 ft. sides. The cost of shoveling from hopper bottom cars would be more, as is shown by the fact that the prevailing price for which coal is unloaded by hand at Brantford, Ont., is 30 ct. to 40 ct. per ton. These figures Mr. Jackson considers as fairly average prices.

Shoveling by hand obviates demurrage, but entails an expenditure of almost as much as the unloading charge for reloading again into the wagon, while the reloading by hand into motor trucks higher than wagons would probably bring the cost of reloading up to 30 ct. per ton. This method, however, of handling stone is primitive and entails having other work available at which the gang of shovelers can be placed until another car is spotted, and it is probably practiced only for small quanties of materials, as the cost is not likely to be less than 50 ct. per ton.

Shoveling by hand out of cars direct into wagons or trucks is obviously much cheaper than the first method, because it entails handling the material once only instead of twice, but it costs more than one handling of material. This is by reason of the time lost by the teams standing idle while they are being loaded. With men at 40 ct. and teams at 80 ct. per hour, and with 1½-yd. wagons, Mr. Jackson found the cost of unloading cars to be 31 ct. per ton. These were flat-bottom cars and the teamsters shoveled, and the increase in cost over shoveling onto the ground was due to the idle time of teams and shovelers, principally the former.

Earth Road Maintenance With Jointed Blade Maintainer

The following suggestions on the use of the jointed blade maintainer were given in the December report of the Department of Public Works of Nebraska.

The patrolman operating a jointed blade maintainer should always have the blades sharp. He should provide himself with an extra set, so that his machine will not be laid up when it becomes necessary to sharpen the blades.

The machine should be well greased. This means that all working parts must be thoroughly lubricated including the chains of the raising and lowering devices.

In operating a maintainer it should be thoroughly understood that the machine is designed for maintenance alone, and not for grading the road.

The blade should always be set level with the bottom of the front and back wheels.

In making the first round the outer blade should be in the ditch at a slope corresponding to the finished cross-section of the road. The remaining blades should be set to conform to the finished surface.

The inside slopes of the ditches must be kept free from weeds; unless this is done the maintainer can not be worked successfully. This slope is the source of supply of clear dirt for building up the shoulder of the road, also all of the dirt that is washed into the ditches by rain is brought to the road over the inside slope of the ditch.

The best time to use the maintainer is when the earth contains moisture enough to work well and not stick on the blade.

The best speed to operate the maintainer is from 4 to 5 miles per hour.

The object of the maintainer is to cut off bumps and fill depressions. For a while the operator will be called upon to use some skill in accomplishing this, but after a while he will have the road in such shape that the amount of dirt carried in front of his mould board will be uniform. The road then will be in perfect shape, and practically no adjustment of the blade will be required by the operator.

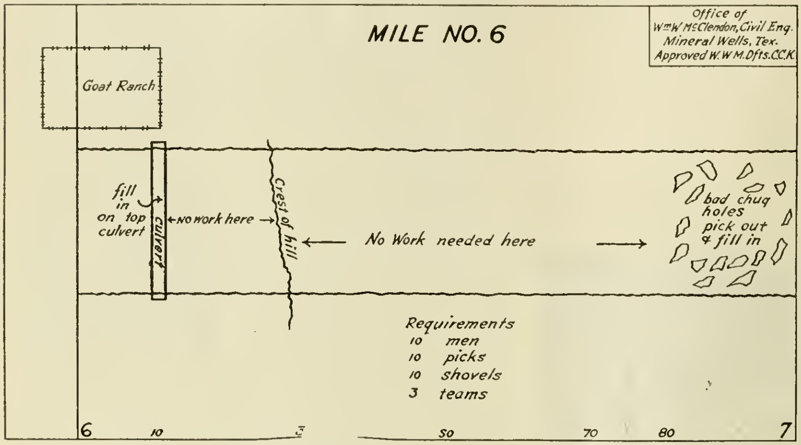
A truck or tractor is the best power for a maintainer.

A complete outfit motor power and maintainer require two men—one driver, and one operator.

Thorough Organization and Definite Plans Make "Good Roads Work Day" a Success

By WILLIAM W. McCLENDON
City Engineer, Mineral Wells, Tex.

The rapid development of the West Texas oil fields has resulted in a greatly increased traffic on the highway from Mineral Wells, Tex., to the Stephen's county line, a distance of 35 miles. This increased traffic was very large. In fact the road carried an average of 67 vehicles per hour for a period of 10 hours per day. Of this total 45 per cent were trucks, the average load of which, exclusive of the weight of the truck was 5 tons. Loads as heavy as 10 tons were hauled over the road.



One of the Work Sheets Showing Work to Be Done and Labor and Tools Required.

Due to the fact that this boom in the oil fields and increase in traffic took place over night, so to speak, the maintenance fund which the county had to spend on this road was soon exhausted and the road was left to take care of itself for such a time that, under such heavy traffic, it became almost impassable.

The citizens of Mineral Wells, in connection with the oil companies, raised $10,000 to be spent toward permanent improvement on this road. The sum was augmented by a like amount from the county and $20,000 from the state highway commission. It was agreed that this money should be spent on the road west of the town of Palo Pinto.

A survey of this section of the road by the M. V. Smith Co., engineers, showed that due to the mountainous country the construction on the first 10 miles would be very heavy, and would far exceed the sum of $40,000, the drainage structures alone averaging 3½ culverts and 2 bridges of not less than 20-ft. span per mile. In connection with Mr. Smith, the writer prepared estimates and plans of this road which showed that the permanent construction would be limited to a 4-mile stretch, leaving the last 18 miles still in a bad condition. Something further, therefore, had to be done toward improving this road. Efforts to vote bond issues for the improvement of road, having failed, an idea was originated at a meeting of the local chamber of commerce that the citizens of Mineral Wells have a good-roads working day. Committees were appointed to visit the local business men to see if the idea met with their approval and to ascertain what per cent of them would be willing to close their places of business for that day. At the next meeting of the chamber of commerce, committees reported 100 per cent favorable.

One of the Gangs Working on Its 1-Mile Section.

Being familiar with needs of the road, and knowing that no particular good could be accomplished unless a thorough system of organization was had and definite plans prepared, the writer offered to donate his services to work out such a plan. A committee on arrangements was then appointed to assist in carrying out the plans. After this had been done, the day for working the road was set for Oct. 23.

In connection with the M. V. Smith Co., engineers, P. E. Bock, a former engineer, the present manager of the chamber of commerce, the writer made a log of the 35 miles of road from Mineral Wells to the Stephens county line. In taking the log, a complete survey by tenths of a mile was made, using a speedometer on an automobile. Notation was made on the ground of every chuckhole and mudhole; good and bad bridges and culverts and their location; suitable road material and gravel pits within three miles of the road, and from mile to mile, the approximate amount of material to be put in each section of the road, was calculated. It was decided to make all plans alike on straight sections 12 in. long and 6 in. wide, numbered from 0 to 35 and to bind in book form. All the data obtained from the road log were put on these sheets. Knowing the amount of work to be done and the time in which to do it, as well as the location of material, etc., it was an easy matter to calculate the exact number of men, teams, trucks, picks, shovels and the other equipment necessary to build a mile of road in one day.

These data were also placed on the sheets and notations were made as to what improvements were to be done, so there would be no loss of motion. From blue-printed sheets, made from original drawings, several books were made and presented to the committee for approval. Following this a tabulated list was made of all available men, with their addresses and 'phone numbers, as well as the list of teams, trucks, picks and shovels.

Captains were then selected for each mile of road and, according to his needs, each was given lists of carpenters, laborers, teams, trucks, picks and shovels which would be at his disposal on the day. These captains were held responsible for notifying the men and securing equipment. Each captain was also furnished a blue print of his mile of road.

The committee then secured the consent of the fire chief to have the fire siren blown at 5:00 o'clock on the morning of the 23rd as a warning to every man to be up and at his section of the road by 8:00 o'clock.

Due to the fact that a hard rain came on the 23rd, the date of the working was postponed a week. Rain interfered again, and the date had to be twice postponed, but on Nov. 21, almost 30 days late, the working day came off. The writer, in connection with his partner, A. B. Purnell, of the firm of McClendon & Purnell, civil engineers, acted as general supervisors over the entire 35-mile stretch, keeping things moving and offering suggestions where needed. After making the trip in the morning, and noticing the improvements in the afternoon, it was more than gratifying to see the absolute smoothness with which the organization worked. In one section 20 carpenters, under the captaincy of Henry Withers, a local contractor, tore out and built a new 10-ft. span bridge, 6 ft. high and 18 ft. wide, in 1½ hours' time, which time included setting new posts and filling in approaches.

All business in Mineral Springs was suspended, and the full organizaton, as originally planned, turned out. It consisted of the following: 1,270 men, 1,000 picks and shovels, 175 trucks, 110 teams, 3 tractors, 4 graders, 6 road drags, posthole diggers and sledge, etc.

Where it was almost impossible the day before, 10-ton loads were passing over the road the next day, and, in addition to encountering a hard surface where it was previously boggy, 12 new culverts and 80 new bridges were noted.

That the day accomplished good in more than one way is evident, for at the next meeting of the chamber of commerce a maintenance fund of $2,000 per month was voted to preserve the improvements made.

War Department Report Recommends Construction of Federal System of Highways

The construction of a federal system of national highways is recommended in a report of the war department to the Highways Committee of Congress, made public April 30. The report summarizes conclusions reached as a result of the army convoy of 73 trucks which blazed a trail from Washington to the Pacific coast last summer.

The recommendations of the department include:

That the necessity for a comprehensive system of national highways, including transcontinental, or through, routes east and west and north and south, is real and urgent, as a commercial asset to further colonize and develop the sparsely settled sections of the country and, finally, as a defensive military necessity.

That existing roads and bridges, especially in the sparsely settled sections of the middle and far western states, are absolutely incapable of meeting present day requirements, and until modern types of roads and bridges are constructed, which will permit the rapid movement of heavy motor cargo vehicles during any season of the year and in all conditions of weather, economical transcontinental highway traffic will continue to be but a vain hope.

That the road problems of the middle and far western states are national rather than local problems, as the states, while possessing vast areas and tremendous mileage of highways, have only a sparse population which cannot possibly undertake the needed highway improvement work, which, moreover, is usually of greater importance to the country as a whole than to the individual states.

Slag as Coarse Aggregate for Concrete Pavements

The Indiana State Highway Commission, early in 1919, determined to try out slag or coarse aggregate in a concrete pavement constructed on the Elkhart-Osceola Road. Slag could be delivered for this project either from South Chicago or Joliet, Ill. Various tests of this material were made, the results of which are summarized by C. Gray and F. Kallam of the Commission in the February Concrete Highway Magazine, from which the matter in this article is abstracted.

When it was first proposed to use slag on this project, a small sample was submitted to the State Highway Commission by the Highway Materials Co., South Bend, Ind. Compression tests were made on two 6-in. cubes made up from this slag and a local sand in proportions of 1:1½:3, at Purdue University. These gave strength at 7 and 28 days of 3,060 lb. and 4,890 lb. per square inch, respectively. The slag weighed about 95 lb. per cubic foot and the concrete about 150 lb. per cubic foot.

Later, during the construction of the road, 16 6-in. by 12-in. compression specimens and 10 wear specimens 5 by 8-in. were made from concrete as it came from the mixer. These specimens represented two different gradings of slag used on this road and the proportions used were varied in order to secure a workable and otherwise satisfactory mix. The grading of sand and the two kinds of slag used are shown in Table I.

These specimens were tested at the Structural Materials Research Laboratory, Lewis Institute, Chicago, and the results reported to the Highway Commission through the courtesy of the Portland Cement Association.

Compression tests were made in the usual manner. Wear tests were made in a Talbot-Jones rattler in accordance with the method described by Prof. D. A. Abrams in a paper entitled "A Method of Making Wear Tests of Concrete." Proceedings, American Society for Testing Materials, 1916, Part II, page 194. In this rattler test, 10 blocks 5 by 8 by 8 in. are arranged around the perimeter of a cylindrical drum, 36 in. in diameter and 8 in. long, attached to a horizontal axle. The open end of the cylinder is closed with an iron plate; an abrasive charge of 200 lb. of cast iron balls, consisting of 133 balls 1⅞ in. in diameter and 10 balls 3¾ in. in diameter is put inside, and the rattler rotated for 1,800 revolutions at the rate of 30 r.p.m. The average depth of wear in inches of each

TABLE I—DATA ON AGGREGATES.

		Sieve analysis. Total per cents retained on each size.								
Aggregate.	Source.	100	45	14	¼	⅜	¾	1½	Silt.	Organic impurities
Sand	..	..	94	34	..	0	..	..	1%	O.K.
Slag "A"	Joliet, Ill.	99	99	98	96	92	40	0	...	....
Slag "B"	Joliet, Ill.	95	..	91	80	70	25	0	...	...

TABLE II—COMPRESSION TESTS OF SLAG CONCRETE.
(Test pieces 1-2-3-9-10-11 made Nov. 6, 1919; others Dec. 7, 1919.)

Ref. No.	Slag.	Mix.	Compressive strength Lb. per sq. in.
1	A	1:2:3	3,770
2	A	1:2:3	3,870
3	A	1:2:3	3,710
4	A	1:2:3	3,520
5	A	1:2:3	4,000
6	A	1:2:3	3,800
7	A	1:2:3	3,830
8	A	1:2:3	3,670
		Average	3,770
9	B	1:1¼:3	4,050
10	B	1:1¼:3	4,030
11	B	1:1¼:3	4,110
12	B	1:1¼:3	4,480
13	B	1:1¼:3	4,100
14	B	1:1¼:3	4,130
15	B	1:1¼:3	3,510
16	B	1:1¼:3	*
		Average	4,060

*Destroyed by mistake.

TABLE III—WEAR TESTS OF SLAG CONCRETE
All test pieces made Nov. 7, 1919.

Ref. No.	Slag.	Mix.	Depth of wear Inches.
1	A	1:2:3	.485
2	A	1:2:3	.480
3	A	1:2:3	.495
4	A	1:2:3	.455
5	A	1:2:3	*
		Average	.480
6	B	1:1¼:3	.555
7	B	1:1¼:3	.526
8	B	1:1¼:3	.655
9	B	1:1¼:3	.690
10	B	1:1¼:3	.467
		Average	.580

*Destroyed by mistake.

block is determined by computation from its loss in weight. The test data are shown in Tables II and III.

Compression specimens 1, 2, 3, 9, 10 and 11 (Table II) were made from six separate batches of concrete produced on the job, while the remaining specimens of each mix were composite specimens made from small amounts of concrete taken from a number of batches. This would indicate a high degree of uniformity in the quality of successive batches.

These tests are too few in number to warrant any definite or far-reaching conclusions. They do, however, furnish some very interesting indications of the value of slag as a material for concrete highways. For instance, the fact that the slag containing a larger per cent of dust and mixed with a smaller amount of sand produced a concrete of higher compressive strength and less resistance to wear, throws considerable doubt on the rather general assumption that the compressive strength of a concrete directly indicates its value in resisting wear.

Very little data on wear tests of concrete made in the field have been published. However, a series of laboratory wear tests made in the same manner in the Structural Materials Research Laboratory at Chicago, as an investigation of the effect of consistency and manner of curing on the wearing value of concrete, shows amounts of wear for pebble and crushed limestone concrete ranging from 0.4 in. for concrete made and cured under the most favorable conditions to 2 in. and over for the most unfavorable conditions. This concrete was mixed in proportions, 1 part cement to 4 parts mixed aggregate, approximately the proportions used on the Elkhart-Osceola Road, but the concrete was tested at an age of four months instead of 28 days.

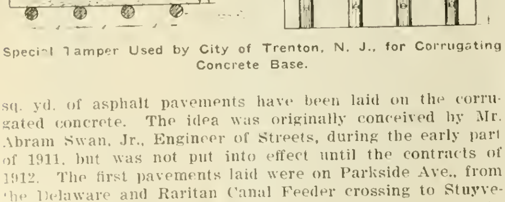
A similar series of tests made at the Structural Materials Research Laboratory on the effect of consistency and time of mixing shows values ranging from 0.46 to 1½ in. for 1:4 gravel concrete at an age of two months.

The results indicate that the resistance to wear and the compressive strength are unusually high for field concrete made under these conditions, and constitute a distinct recommendation for slag as a concrete highway material when properly selected and used.

Eliminating Binder Course of Asphalt Pavements by Corrugating Concrete Base

A specially designed tamper is used by the city of Trenton, N. J., for corrugating concrete base for the purpose of eliminating the binder course in asphalt pavements.

This method and tamper has been in use in the city since the early part of 1912. During the last 7 years over 200,000 sq. yd. of asphalt pavements have been laid on the corrugated concrete. The idea was originally conceived by Mr. Abram Swan, Jr., Engineer of Streets, during the early part of 1911, but was not put into effect until the contracts of 1912. The first pavements laid were on Parkside Ave., from the Delaware and Raritan Canal Feeder crossing to Stuyvesant Ave., and on Hermitage Ave., from W. State St. to Stuyvesant Ave. In both of these instances the pavement was laid on a 5 per cent grade with 1½ in. of asphalt surface directly on the concrete without binder. Both of these pavements, although subjected to considerable traffic and on the excessive grade have never had any maintenance repairs [illegible] wear-outs or creeping. In fact, none of the asphalt pavements that were laid under this method have crept. The asphalt used was generally about 55 penetration.



Special Tamper Used by City of Trenton, N. J., for Corrugating Concrete Base.

The Appearance of Streets*

By PROF. FREDERICK N. EVANS.

The appearance of streets is dependent upon four things:

1. The character or type of street systems use.
2. The type of street as regards its use or purposes.
3. The regulations governing structures, major and minor, along it.
4. Regular street equipment.

Type of Street System Governs Appearance.—To a greater extent than is ordinarily supposed, the type of street system governs the street's appearance. There are four principal kinds of street systems, the irregular or meandering, the concentric, the radial and the perpendicular, commonly called the gridiron or checkerboard. Seldom is any one type used alone in the town plan, even the widespread perpendicular system being usually broken through at some points by highways leading in from the country.

Obviously the way in which the appearance of the street is most particularly affected by the type of street layout used is in the control which the type exerts in terminating the view, or in necessitating or obviating cut and fill in construction. Both the irregular and the concentric type close in the street picture, giving a charming effect, as illustrated in the medieval street or in the purposeful imitations of it in the modern parts of German cities.

In residential subdivisions the curving street line undeniably adds the charm of the unexpected and a certain coziness to the appearance of the streets. It is understood, however, that uneven topography is the best excuse that a street has for curving and that on flat ground street curves are apt to appear out of place and forced. How often have pathetically poor attempts been made to curve streets, which would have appeared better straight!

Radial streets offer numerous opportunities for the interesting termination of vistas at street junctions, as seen in the pre-eminent example of Paris and in a few of the cities of our own country. The lack of termination in the perpendicular system, which quite deservedly bears the name "American system" abroad, is a well known fact, though there are exceptions to this, when the straight street is not carried quite to the horizon. It is not the purpose here to decry the use of any one of the street systems named, as each has distinct advantages under certain conditions. As street planners the proper attitude of mind would be to be willing to use each type when and where it will serve the best end.

Character of Street Differs According to Use.—Streets serve various purposes; for instance, there is the arterial thoroughfare, including broad avenues and highways, the street in the wholesale and industrial sections, the street in the retail district, the main residential street, the minor residential street, the parkway and boulevard, and finally the alley. Like the rule of architectural design, which says a building elevation should show the purpose of the structure, so the appearance of the street in cross section should conform to the function of the street.

Standardization of street width over the entire town plan has led to great economic loss—a condition which might be largely obviated. Where the use of a particular street may undergo possible change, the distance between curb and sidewalk may be made wide enough to allow for the future widening of the street pavement. A suggestive and helpful diagram of street cross sections for various types of streets is that published in Volume 2 of the Report of the U. S. Housing Corporation, published by the U. S. Department of Labor, being an especially valuable reference for desk use on suburban land development.

With the regulation of building heights, front building line restriction in residential neighborhoods and efforts working for the elimination of signs and billboards, we are already familiar. The effect of such regulation upon the appearance of the street is at once apparent. Closely related to this effort at clearing up the unsightly is that of doing away with poles, wires, encroaching steps, and such things, including also advertising clocks standing near the curb. Besides the effect on traffic movement and insuring greater safety, there is exerted a wholesome effect upon the appearance of the street.

All will probably agree that the pavement should be made no wider than is necessary to accommodate traffic along it.

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*From a paper read at the last annual meeting of the Illinois Society of Engineers.

If width in appearance is desired, getting it by putting down an expensive pavement is a costly way to go about the matter. The appearance of width to the street can be gained effectively by having a narrow pavement and ample parkings, by putting in a center parking, or again by keeping trees off the parking entirely and planting them just inside the property lines. To cite a single example of a street in Cleveland, O. The Shaker Heights Improvement Co. put in a number of streets, having the pavement but 26 ft. wide, side parkings of 11 ft., sidewalks 5½ ft., and with 1 or 2-ft. reservations on each outer edge between sidewalk and property line. These streets appeared impressively wide after construction and paving costs were low.

Center Parking Asset to Street's Appearance.—In the case of the center parking one is led to paraphrase what was once said of liberty, "What crimes are committed in thy name!" Unless given a proper width and proper planting, and unless assured proper upkeep, the center parking had best be omitted. When rightly done, however, this feature is an asset to the street's appearance, belonging naturally only to the major residential street, the parkway or the boulevard.

Too often the center parking of our streets, instead of functioning as a part of the street, appears as a narrow green ribbon which apparently a forceful wind might blow away. If a single rule might be laid down in this matter, it would be that a center parking ought to be as wide or slightly wider than the roadway on either side. There is not time to enter into a thorough discussion of its planting or ornamentation except to say that nothing should be placed in it which will give the effect of dividing the street in half. Generally trees in the parking would seem permissible only if there are trees of good height in the side parking. An exception is when the parking is wide enough to carry a walk down its center, as on Commonwealth Ave., Boston. On narrow parkings, light standards, high shrubbery, or other prominent street furniture will surely narrow the apparent width of the street.

Modern concrete gutters and curbs in one piece claim a permanent place in roadmaking and have a good deal of merit providing they are carefully laid. The sandstone curb dressed with slight longitudinal ridges, and a generous nosing or rounding off possesses a texture and excellence in color that is hard to surpass in artificial stone.

Grass gutters or gutters of stones with grass edges are appropriate for streets of suburban character. The difficulty lies in keeping the edges from growing ragged and from being cut by wheels which draw close to the roadway border.

In present day work the benefit of giving the curb a generous radius at the corners is generally recognized, particularly in subdivision work, where in residential sections it is the aim to get away from mechanical appearances. We find that from 4 ft. the curb radius has increased to 20 ft. more or less.

Side Parkings and Walks.—The handling of the side parking is extremely important, since by means of a generous parking, even a narrow roadway may be used without constricting the effect of breadth. No side parking should be under 4 ft. in width, this being the minimum for street tree growth. Parkings between curb and sidewalk are sometimes omitted without such disastrous effect to appearance as might be imagined. This is to be done only on narrow residential streets and those in the downtown district.

Sidewalks, like roadway widths, vary according to the use expected of them. A proper width upon which to base calculations for each line of foot traffic is 2 ft. In residential sections 4 ft. is about the minimum and 6 ft. the maximum for ordinary use. It is not a new principle to state that considerable leeway may be allowed for variation of height of sidewalk above the pavement; indeed, pleasing effects are thus secured, such a change from the regular way of doing things being economical as well as attractive.

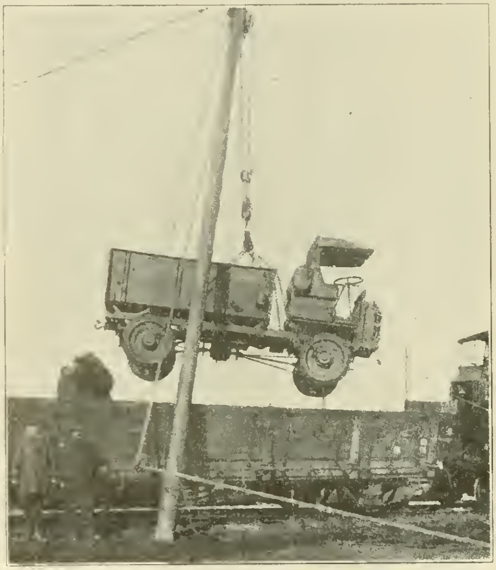
Trees affect the appearance of streets and highways as much as any other one thing. They are on the boundary between necessity and ornament. They should be of uniform size and variety along each street, and best planted about 40 ft. apart. At corners, it is of benefit to traffic safety and to appearance to keep trees back about 20 ft. from each corner. This gives a wide circle of eight trees instead of the usual four, adding a good deal to the dignity of the street.

Street Equipment.—By the form of its lighting standards, street name signs, post boxes, and many other pieces of street furnishings the appearance of the street is directly affected and to an extent which makes these very things of vital consideration. It is a single law of attention that the eye tends to pass over broad surfaces and come to rest upon small prominent objects. Important, then, is the form to be given these minor objects of street equipment.

Each one in whose hands lies the placing of such equipment should allow his desire for doing the individual thing to be tempered by conformance to what is restful and dignified rather than odd and startling. It is hard to define good taste, but it seems to consist largely in doing simple things well, doing them frankly, and basing choice upon the best of what has been done in the past.

Gin Pole Aids in Unloading Trucks from Open Top Cars

A gin pole with block and tackle solved the problem of unloading a train load of trucks for the Iowa Highway Commission. The trucks were shipped by the U. S. War Department in open cars of a type of which neither ends nor sides could be lowered or removed. The accompany illustration, reproduced from the Iowa Highway Commission Service, shows the method employed.



Unloading F. W. D. Truck with Gin Pole.

Graduate Short Period Courses in Highway Engineering and Transport.—During the months of December, 1920, to March, 1921, inclusive, the University of Michigan will offer the following 17 graduate short period courses in highway engineering and highway transport:

American and English highway transport methods; highway transport surveys; interrelationship of highways, railway and waterway transport; American and English highway traffic legislation and regulations; highway transport management, costs and record systems; highway transport seminar; highway engineering financing, administration and organization; highway engineering theory and design; highway laboratory; bituminous materials; grading machinery and operation; earth, sand-clay, gravel and broken stone roads; bituminous surfaces and bituminous pavements; brick, cement-concrete, stone block and wood block pavements; highway specifications, contracts and jurisprudence; highway structures; highway engineering seminar.

Each course will consist of 30 lectures and be given in a period of two weeks. The time schedule of the courses will be announced later. Each course will count as two hours' credit towards the total of 24 hours required for the master of science degree. The fee for each course will be $10.

Cost of Road Dragging in Iowa.—During 1919 a total of 16,221 miles of highway in Iowa were dragged regularly. The cost of this work averaged $41.80 per mile. In 1918 the average cost per mile was $31.02 and in 1917 it was $24.04.

Contract Clauses That Tend to Work a Hardship on the Contractor*

By ROYAL A. STONE,
Attorney-at-Law, Minneapolis, Minn.

In one contract that we opened some time ago, we found in the specifications, and very deep in the specifications, sunk way down in the fine print towards the end, the following paragraph:

> Any omission to disapprove of the work of the engineer at the time of the monthly or other estimate being made, shall not be construed to be an acceptance of any defective work, etc.

The draughtsman of the particular contract went just as far as possible to confuse—he may not have intended to, but that was the result—so that the careless contractor might very easily be led into signing that contract without actually knowing what was in it. Thousands and thousands of such contracts have been signed by parties who knew what was in them.

The paragraph is objectionable from another standpoint. This work must necessarily be done pursuant to the designs and under the direction of the engineer; but tell me, if an engineer comes along with a piece of railroad work or drainage canal and sees that the piece of work is being done improperly, that the structure is contrary to the specifications, that it is inherently weak, has he any right to pass it up and in six months hence, after you have gone and after the outfit is moved somewhere else, to spring this specification and say, "You have got to go back and do it all over again?"

I think that a fair provision would be along this line:

> The failure of the engineer to disapprove in writing of any work claimed to be defective, as soon as the alleged defects are discovered or in the exercise of reasonable diligence shall be discovered by him, shall be deemed an acceptance of the work in question.

This is the rule which would be applied in court were it not for the contrary controlling provision of the contract.

Extra Work and Changes of Plans.—Here is another very common provision, and in substance, a necessary provision:

> The engineer may * * * order extra work to be done or make any changes he may deem expedient * * * and may furnish other plans. * * * All such extras and changes must be directed by the engineer in writing, who shall fix the amount by which the cost of the work is increased or diminished. * * * Claims must be made monthly and * * * shall only be allowed when the engineer has in writing authorized same and stated the prices to be paid therefor.

In substance, that is a necessary provision. It is the result of experience, but knowing that the legal profession is very fallible and that all of the inferior professions must be fallible, I think it is altogether too much power to grant the engineer. "He may furnish other plans"; he may change the whole scheme of the work, change the location, and absolutely disorganize the plans of the contractor. He may do it at any time after you have your outfit placed and after your work is started, and those provisions are the only covenant; and the other clause denies you any recovery for any loss of anticipated profits by reason of any such change.

I do not think the engineer ought to have a right so to change the plans that the entire nature of the work, from the contractor's standpoint, is changed. The contractor should have a right to elect—"I will go on with the work and perform the contract under your price, or I am through. You will pay me for my expense and loss of time." I think that would be a reasonable way to take care of a situation of that kind.

It is understood that in the event an engineer orders changes and extra work, the price fixed by the engineer must be a reasonable price. I think the contract ought to be so worded as to protect the contractor as to that phase of the question.

Now, to illustrate just what happens when two engineers fix the price. I was out on a trip recently, in connection with a project under construction, and the engineer for the public fixed the price of raising a piece of industrial track and a few hundred feet at $5,000, and the engineer for the railroad company fixed the price at $12,000. In a situation of that kind the contractor ought to be protected and it ought to be left for him to say whether he will go ahead or quit, and if he elects to quit, he ought to be paid for what he has already done.

Waiving Contract Provisions.—If you are bound by such a contract you have a right, in case of any such change, to get that amount fixed in writing before you proceed. Sometime I hope to find the case of a contract where a contractor who, when such provisions are in the contract, will insist on having in writing that which he is entitled to have in writing. So far such cases have been very few and far between. You have relied on the good faith of the engineer, but the trouble is, despite the best efforts of the engineer, despite his honesty, notwithstanding your own good faith, and your own constant efforts to complete your contract, you may get into court. That contract comes to a lawyer; he picks it up; he is there to protect the rights of his client, and his client may be the owner. The owner has the right under such a provision, before becoming bound by any charge for extras, to have it fixed in writing. The lawyer says at once, "Why, you are not liable for this. The matter was not determined by written decision of the engineer before he went ahead with the work."

There can be no recourse. What is the alternative for the contractor? This may represent the entire profit on the job, and that item may be the difference between future prosperity and temporary ruin—financial embarrassment. He can prove—he may attempt to prove—that that and other provisions of the contract have been waived. You can get away with it, ordinarily, but it is a costly proceeding.

When you are entitled to have anything in writing be sure that you get it and get it when you are entitled to it. It is an easy thing to overlook in the rush and press of work, but remember that the work is being done under a contract binding upon yourself, under written language, which will be interpreted in the end by somebody other than you and the other contracting party who adopted it, so check yourself up as you go along with the work and get that to which you are entitled.

Another provision happens to accompany this:

> The contractor shall keep a competent foreman * * * to be engaged and retained only with the approval of the engineer.

I do not think such a provision ought to be allowed in any contract because they are generally provisions which protect the owner. To give the engineer, in the ordinary case, power to discharge your foreman and select another one for you is taking the work out of your hands to such an extent as none wants to consent to in advance.

Claims for Extra Work or Material.—Here is another one along the lines of extra work.

> All claims for extra work or material must be presented to the engineer for allowance at the end of the month.

So far so good. The owner has a right to demand that. The engineer is entitled to it. It is a matter of fair dealing between man and man.

> * * * in which the same shall have been done or furnished, and shall, if allowed by the engineer, be included in the estimate for that amount; otherwise all claim therefor shall be deemed to be absolutely waived by the contractor.

In other words, mere omission by your superintendent may cause you a loss beyond the power of your engineer to rectify, because your engineer cannot change this contract. If the engineer wants to put that in the estimate a couple of months hence, he will have the trouble doing it against the efforts of the lawyer and the court, if the matter finally gets into court. Again, of course, you have the recourse of the waiver of provisions of that kind, but it is a dangerous recourse. It is an attempt to cure where prevention should have been used.

And right along this same line, read this:

> Every allowance * * * shall be embraced in * * * monthly estimates; but should the contractor have a claim which he considers is not included in any progress certificate, it will be necessary for him to make such claim in writing to the engineer within thirty days. * * *

That is far enough, but read this:

> Unless such claims are thus made and are repeated in writing every month until finally adjusted or rejected, the contractor shall have no recourse against the company.

How many contractors have signed that contract? It has been very common. No owner's or company's protective provision is more common.

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*Abstract of an address presented Feb. 23 at the annual convention of the Northwestern Association of General Contractors, Minneapolis, Minn.

Delays Caused by Owner.—Study this:

> The only recourse of the contractor in case of delay caused by the company is an extension of time for a period equal to the delay, and the right of the contractor to such extension shall be deemed to have been waived unless a claim therefor, stating the occasion and nature thereof, shall be made by him in writing, delivered to the company at the time of such stoppage or delay.

Another:

> If there be any delay in the work, upon the written directions of the company, or by reason of any cause for which the company is held responsible, the contractor shall have no claim for damage by reason of such delay, but the time specified for completing the work shall be extended for a period of time equal to the time of such stoppage or delay.

Notice the requirements, not originally, but as the work proceeds along:

> The contractor shall be at the risk of, and shall bear, all loss or damage whatsoever, and howsoever arising, which may occur to the work, until the same has been accepted by the company, and all damage occurring before acceptance shall be made good by the contractor.

That is, if you complete a piece of grade or any other work, although it is done so far as you are concerned, and the company delays you, causing you to lay up during the winter season, during the season of heavy rains, during the season of greatest activity of disintegrating frost in the spring, through no fault of your own, the engineer has the right and it is his duty under that contract, to make you go back and do the finishing work over again, a very, very costly proceeding in some cases. Under such a provision an engineer by willfully delaying acceptance of the work, may impose upon the contractor, not only a risk of damage, but a very, very certain conclusion that you are going to be damaged to an extent far beyond your profits.

The Lien Clause on Contractor's Outfit.—Here is a provision that is unusual, with which you may disagree, because you may have seen it more than I have:

> All machinery and plant provided for the work shall * * * become and, until completion of the work, remain, the property of the company, for the purpose of said work, and shall not be removed or be disposed of other than for said work, without the consent in writing of the engineer. Provided, however, that upon completion of the work and upon payment by contractor of all moneys due from him to the company, such of the machinery, plant and materials as shall not have been converted in the works and remain undisposed of, may be removed by the contractor, at his own expense.

In other words, the builder, in that case the owner, or company, makes you give him a lien upon your entire outfit for the security, first, of your execution of the work, and, second, for the security of any sum which you owe the company for the privilege of working for him. What is the effect of such a provision? I do not believe it is equitable. I do not believe that the sense of the contractors of the Northwest—I do not mean that as a question of the good sense of your combined judgment—is going to tolerate the continuation, if it is being used, of the use of that provision.

Release of Contractor's Claims.—And here is the supreme limit in the way of language of some general counsel somewhere—I won't tell where—I happen to remember the contract myself—in the way of inserting into a contract a provision unquestionably unfair, absolutely damnable in the injustice of the uses to which it may be put.

> Delivery to the company, if required, of a valid release of all claims in respect to matters connected with or arising out of this agreement; the furnishing of such certificate, evidence and release being a condition precedent to the right of the contractor to receive payment in respect of the final estimate.

In other words, if you get to the fighting point and want to sue on account of the work you have done, before you sue you have got to acknowledge receipt of payment of that work. That is what it amounts to, and that, more than anything, is a good illustration of the extent to which gentlemen of my profession, working for only one side of an interested group, as they should—for lawyers cannot serve two masters any better than anyone else—that is an illustration of the extent to which that system goes. The remedy is for these contracts to be drawn as other contracts are drawn, so as to represent the combined judgment of the owner on the one side and the contractor on the other, as to what is fair concerning the work to be accomplished.

Hereafter, that sort of contract can be worked out by this organization by your joining forces. It is certainly within your power to compel the elimination from the contracts under which you must proceed, of any such provision as that. If that contract is drawn by one party, of course, it represents the interest of that party, whether he is the owner or the contractor, and the general conclusion, the general recommendation to which I want to call your attention, is that hereafter contractors owe it to themselves to see that the contracts under which they execute their works represent their ideas as well as those of the owner.

Factors in Financing State Wide Highway Improvement*

By T. L. AGG,
Professor of Highway Engineering, Iowa State College, Ames, Iowa.

The financing of extensive surfacing projects involves very large sums of money, but conditions during the past few years have been favorable to highway financing so that comparatively little difficulty is experienced in obtaining money for road improvement. Looking to the future, however, it must be apparent that the completion of the projects now in contemplation in the United States will involve such enormous sums of money that a foundation of sane financing must be laid at the earliest possible moment. This is particularly true now that it is so generally recognized that an appreciable percentage of the highways of the nation must be constructed of such a character that they will be adequate for motor transport, of both high speed passenger vehicles and slower speed, heavy freight vehicles. Construction of this character is costly, although the cost is probably far below the actual benefit to the communities traversed.

It may be within the province of this paper to mention briefly some factors that can properly be considered to have a bearing on the determination of a rational system of financing state-wide highway improvements.

It is believed that a system of financing that is in a general way based on distribution of cost according to benefits is justifiable and will be proof against claims of unjust discrimination in taxation for road improvement. The almost insurmountable difficulty lies in devising a means for determining where the benefits fall or the extent of the benefit in any direction.

Probably no one questions that an area that is liberally served with railroad facilities derives therefrom a community benefit that may seem to be somewhat intangible yet is nevertheless real. The benefit becomes apparent when such a community is compared with one not so favored. In the same way, the construction in any community of adequate highways of year-around serviceability for motor transport, confers a real benefit on that community. A part of the cost of such an improvement might therefore properly and equitably be paid from general taxation in the district served. But the possibility of the district profitably utilizing the facility will vary greatly with the nature of the industries in the district and it is doubtful if any fixed percentage to be assessed as a general tax would be equitable for an area even as large as a state. Differences in assessed valuation of land would, however, tend to equalize taxation to a great extent even though the rate of taxation is uniform.

There is also a direct and tangible benefit conferred on agricultural land by the construction of improved roads contiguous thereto. Lands on good roads are worth more than those not so situated and will actually sell more readily and at a higher price. The land can actually be made to show better profits when located on a good road than when not so located, because of the greater facility with which it can be operated. Therefore a certain part of the cost of durable improvements can rationally and fairly be assessed against such lands. The percentage of the cost to be so assessed is not easily determined, but certainly should not in many cases exceed 25 per cent of the total cost.

It probably will be admitted that the most apparent and tangible benefit from road improvement accrues to those who actually travel the highways for business or pleasure and since about 95 per cent of the tonnage of the nation's highways is made of various classes of motor vehicles, it follows that to them the benefit of improved roads is most apparent.

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*From a paper presented Jan. 29 at the annual convention of the National Highway Traffic Association.

The cost for fuel, for vehicle upkeep and the saving in time on improved roads are real and measurable benefits.

Some tests of a preliminary nature were made at Ames to determine the difference in gasoline consumption on various types of surfaces. While these were too few in number to be conclusive, they indicated 20 per cent as the possible saving between an average earth or gravel road and a high-class paved surface. This would mean a saving on motor operation in Iowa of upwards of $3,000,000 a year. It is equitable to require the owners of motor vehicles to contribute somewhat to the cost of the improvement of the highways and very largely to the cost of maintenance. This has been recognized in recent legislation in several states.

The amount that is added to the cost of a road because it must accommodate motor truck traffic can hardly be taxed against other than owners of motor trucks and it would seem probable that in the future both trucks and passenger vehicles will be required to bear an increasing portion of the cost of road construction and maintenance.

In the whole problem of highway finance, it is necessary to recognize that a roadway is being provided as a transportation facility that is not operated for direct income and the incentive to keep accurate account of the use of the facility in order to place the cost where the benefit is realized is lacking. Nevertheless, the great highway system desired by all progressive citizens can never be fully completed and maintained unless the financing is placed on a sound economic basis.

Cost of Snow Removal With Rotary Plow

A rotary snowplow has been used at Outremont, Que., in clearing the streets of snow. The plow is mounted on sleds, and is drawn by horses. The blades are operated by a 60-HP. marine engine. The snow is pulverized by the blades and projected upward and then out through specially devised samples. In a discussion of a report presented to 1919 convention of the American Road Builders' Association, Capt. J. A. Duchastel, City Engineer of Outremont, gave the following data on work done by the machine in 1917-18:

In one instance the work consisted of removing a bank of snow on each side of Cote St. Catherine Road. This snow had been piled up at a distance of 10 ft. from the car track by the Montreal Tramways snow leveler. The bank was about 10 ft. wide and 1 ft. 9 in. high; the snow was very compact. The cost was worked out in the following manner:

After allowing a depreciation of 10 per cent on the cost of the machine, interest at the rate of 7 per cent, and $241 per year for repairs, it was figured that the fixed charges per day for the machine for a period of 50 working days during the season, was $14. Figuring the cost of gasoline, the time of the operator, the corporation teams and helpers, as well as the time of a grader and snowplow used in connection with this work to remove whatever accumulation of snow was deposited on the sidewalks by this machine, it was found that the cost per lineal yard of cleaning one side only was 7.65 ct. This work covered a period of 23 hours and a bank of snow 6,775 ft. long, 10 ft. wide, and 1 ft. 9 in. high, was cleared in that time. Naturally that was not continuous work.

As a parallel to this work, the cost of removing snow on the same date on another section of the same road, under exactly the same conditions, was kept, the snow being loaded by hand in sleighs and removed to a dump less than ¼ of a mile away. The cost per lineal yard was 23.7 ct. This work covered a period of 10 hours and a bank of snow 950 ft. long, 10 ft. wide, and 1 ft. 9 in. high was cleared. As a check on these figures, the cost of clearing Cote St. Catherine Road by the second method in the previous year was locked up, and it was found that the cost was 27.4 ct. Probably the bank was, on the average, a little bit higher.

St. Louis Convention of the A. A. E.—Among the speakers [illegible] the sixth annual convention of the American Association [illegible] Engineers to be held at the Planters Hotel in St. Louis [illegible] May 10 and 11 will be M. O. Leighton, chairman of the [illegible] service committee of Engineering Council, who will [illegible] on "Getting Salaries for Public Service Engineers Into [illegible]. Francis A. A. Kellor, vice-chairman of the Inter-[illegible] Council of New York and a recognized authority on [illegible]tion and racial problems, who will speak on "The [illegible] Engineer—The Opportunity of Americanism," and [illegible] of the American International Corporation of New York who will speak on "Opportunities for the Engineer." The principal speakers at the banquet on May 11 will be Doctor F. H. Newell, president of the American Association of Engineers and head of the department of civil engineering at the University of Illinois, and L. K. Sherman, president of the United States Housing Corporation. A feature of the convention will be group meetings for draftsmen, federal engineers, mining engineers, highway engineers, industrial engineers, chemical engineers, municipal engineers and railroad engineers. These meetings will be held on the evening of the 10th. They will consider problems peculiar to each group and make a report to the general business session on the following day.

Personals

Myron E. Downie has resigned as county engineer of Dubuque County, Iowa.

G. A. Russell has been appointed county highway engineer of Geary County, Kansas.

Harvey J. Salter, for several years county surveyor of Siskiyou County, California, has been appointed county road engineer.

Oswald Lind has resigned as county highway engineer of Wilkin County, Minnesota. He is succeeded by H. E. Palmer, Redwood Falls, Minn.

John Brumbaugh, a road contractor, has been appointed county road superintendent of Huntington County, Indiana, succeeding John P. Hacker, resigned.

Dan Gardner, L. A. Owen and Grace M. Gardner have organized the Gardner-Owen Construction Co., Coldwater, Mich., and have engaged in road contracting.

James R. McCamman, Charlotte, Mich., has been appointed county surveyor of Eaton County, Michigan, to fill the vacancy caused by the death of Morrell Newcomb.

W. K. Seitz has been appointed city engineer of St. Joseph, Mo.

V. D. Johnson, Shenandoah, Va., has been appointed engineer in charge of street construction for Roanoke, Va.

C. V. Cheatham, for 17 years engaged in engineering in western Montana, has been appointed senior highway engineer for the U. S. Bureau of Public Roads in the district of Alaska.

Courtney C. Washington, resident engineer of the Santa Fe Ry. at Galveston, Tex., has been appointed county engineer of Galveston County, Texas, succeeding Robert M. Sias, resigned.

Van E. Lawyer, for the past 12 years county superintendent of highways for Schoharie County, New York, has resigned to accept the position of district supervisor for the New York State Highway Department.

Governor Cooper of South Carolina has named the fololwing as members of the state highway commission which will direct the construction of the state highway system as provided by the act of the recent general assembly, one appointee coming from each congressional district. They are as follows: First district, R. Goodwin Rhett, Anderson; fourth, C. O. Hearon, Spartanburg; fifth, N. G. Walker, Rock Hill; sixth, Frank Manning, Jr., Bennettesville; seventh, A. B. Langley, Columbia.

Industrial Notes

The New-Way Motor Co., of Lansing, Mich., which for the past 15 years has been making a full line of air-cooled stationary engines, has standardized its plant at Lansing for the production of one engine only.

The T. L. Smith Co., Old Colony building, Chicago, is distributing among paving contractors a booklet for recording bidding prices. The book is leather bound, 4¾x8 inches in size. A pad with sheets ruled for this special purpose makes the book useful for recording the road bids entered on the various jobs.

J. Hampton Baumgartner has resigned as assistant to the president of the National Association of Owners of Railroad Securities, to become president of the Baumgartner Advertising-Publicity Co., recently established. With Mr. Baumgartner in his new business will be R. M. Kureth who has been associated with him for the past ten years, and J. Erle Baumgartner, formerly in the sales organization of large mercantile interests on the Pacific Coast.

H. S. Rosenthal has associated himself with the Chain Belt Co of Milwaukee, Wis., and has taken up his duties as southern district sales manager for Rex mixers and pavers. Mr. Rosenthal will have complete charge of the sales in Texas, Arkansas, Louisiana, Mississippi, Alabama Florida and Tennessee and will establish new sales connections besides assisting Rex representatives in his territory. Before joining the "Rex family" Mr. Rosenthal was field sales manager for the Waterloo Construction Machinery Co. and was also connected with the Clyde Iron Works. During the war he served as a captain in the U. S. Army Engineer Corps.

Trade Publications

The following trade publications of interest to engineers and contractors have been issued recently.

Road Machinery.—Smith & Sons Mfg. Co., 1508 Guinotte Ave., Kansas City Mo. 40-page catalog describing the Royal road building machinery.

Gasoline Dump Truck.—Clark Tructractor Co., 1130 Michigan Ave. Chicago. 12-page illustrated pamphlet on use of Clark tructractor in road building.

Subgrading Machine.—Lakewood Engineering Co., Cleveland, O., 16-page bulletin describing use of Lakewood subgrader in preparing subgrade for concrete roads.

Road Oils.—The Texas Co., 17 Battery Pl., New York City. 21-page booklet on the use of Texaco road oil. Contains several tables of interest to road builders.

Steel Forms for Roads and Streets.—Blaw-Knox Co., Pittsburgh, Pa. Circular illustrating and describing the use of steel forms in constructing roads, curbs, combined curb and gutter and sidewalks.

Tractors.—Holt Manufacturing Co., Peoria, Ill. 32-page booklet illustrating performances of the "Caterpillar" in this and foreign countries. Illustrations show many uses of the tractor in the construction field.

Road Machinery, Culvert Pipe, Etc.—Galion Iron Works & Mfg. Co., Galion O. 48-page catalog describing the essential features of the road-making machinery specialties and culvert pipe manufactured by this firm.

Waterworks and Hydraulics Monthly Issue

ENGINEERING AND CONTRACTING

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Roads and Streets—1st Wednesday
(a) Roads (c) Street Cleaning
(b) Streets (d) Municipal Miscellanies
(e) Management and Office System

Waterworks and Hydraulics—2nd Wednesday
(a) Waterworks (c) Irrigation and Drainage
(b) Sewers and Sanitation (d) Power and Pumping
(e) Management and Office System

Railways and Excavation—3rd Wednesday
(a) Excavation (c) Quarries and Pits
(b) Management and Office System (d) Steam Railways, Construction and Maintenance
(e) Electric Railway Construction and Maintenance

Buildings and Structures—4th Wednesday
(a) Buildings (d) Miscellaneous Structures
(b) Bridges (e) Properties of Materials
(c) Harbor Structures (f) Management and Office System

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Is America Producing Less Than Before the War?

Let a statistical falsehood once get into the daily press, and a prompt recantation rarely follows even when it is proved that the data were incorrect. Thus, it was widely published some months ago that American productivity had greatly decreased, and that this accounted largely for high prices. As a matter of fact, however, our total productivity was never so great as in 1918, and although there was some decrease in 1919 it was still greater than in 1913.

The 20-page article by Mr. Gillette in the April 7 issue of Engineering and Contracting gave the facts as to our national output in 1918, which we will now supplement by data as to 1919.

Table 1 gives the nine leading farm crop quantities for the years 1913, 1918 and 1919, priced out at standard unit prices. These nine crops total in value 85 per cent of the value of all our crops. Moreover, there is an almost constant relation between value of crops and value of animal products in America.

It will be observed that every crop, except cotton and barley, was greater in 1919 than in 1914: and the total value of the nine crops (at prewar prices) was 15 per cent greater in 1919 than in 1913. Corn was 28 per cent greater, and hay 42 per cent greater in 1919 than in 1913.

E. and C. Now $4 a Year

The greatly increased cost of all items entering into the production of Engineering and Contracting makes it necessary for us to increase the subscription price to $4 a year. The specialized monthly issues can be subscribed for, as heretofore, at $1 per year. We have realized for some time that we would have to increase our subscription price but have delayed taking the step in the hope that changing conditions would make such action unnecessary. We are now obliged, however, in view of the increased scale of costs in all branches of our business to definitely announce the advance in subscription price to $4.

About half the total number of workers engaged in producing commodities sold at wholesale are farmers. Hence if they produced 15 per cent more in 1919 than in 1913, the remaining producers of wholesale commodities (the miners and manufacturers) would have to show a decrease of 15 per cent in order to offset the 15 per cent increase attributable to the farmers.

Let us see what the miners did.

Table 11 shows the output of the seven principal minerals for the years 1913, 1918 and 1919, priced out at standard unit prices. These seven minerals aggregate in value 85 per cent of our total mineral production. It will be seen that while the total equated value for 1918 was about 20 per cent in excess of 1913, that for 1919 was practically equal to that of 1913. Had the production of gold and silver not decreased in 1919, there would have been almost no difference between the mineral output of 1919 and 1913.

Bearing in mind the fact that our metal manufacturing trades vary in volume as our metal mining varies, it is evident that no marked difference between 1913 and 1919 existed in that branch of manufacturing. In 1913 our production of pig iron was 30,966,000 tons; in 1918 it was 39,052,000 tons; and in 1919 it was 31,015,000 tons; hence 1913 (which was the largest pig iron year in the history of this country up to that

TABLE 1—FARM OUTPUT.

Year	Standard unit price.	Millions of units produced. 1913	1918	1919	Mitilons of dollars at the standard unit price. 1913	1918	1919
Corn	$0.55	2,446	2,503	2,917	$1,345	$1,377	$1,604
Wheat	1.00	763	921	941	763	921	941
Oats	0.40	1,122	1,538	1,248	449	615	499
Barley	0.60	178	225	166	107	135	100
Hay	12.00	64	77	91	768	924	1,092
Potatoes	0.60	332	412	358	199	247	215
Cotton	55.00	14.2	11.7	11.0	781	644	605
Tobacco	0.10	954	1,439	1,389	95	144	139
Sugar	0.025	1,710	2,081	1,759	43	52	44
Total					$4,550	$5,059	$5,239

TABLE II—MINE OUTPUT

Year	Standard unit price.	Millions of units produced. 1913	1918	1919	Millions of dolalrs at the standard unit price. 1913	1918	1919
Coal	$ 1.50	509.00	581.00	486.00	$ 764	$ 872	$ 729
Copper	300.00	0.55	0.89	0.54	165	267	162
Iron ore	2.00	60.00	70.00	60.00	120	140	120
Gold	20.70	4.27	3.21	2.83	88	69	59
Silver	1.00	67.60	67.88	55.29	68	68	55
Lead	100.00	0.41	0.54	0.43	41	54	43
Zinc	120.00	0.34	0.53	0.48	41	64	58
Total					$1,287	$1,534	$1,226

time) was slightly exceeded by the output for the year 1919.

The number of bales of cotton used in our mills during 1913 was 5,790,000; in 1918 it was 7,690,000; and in 1919 it was 5,920,000. Hence two of our greatest manufacturing industries (the textile and the metal industries) show no falling off in 1919 compared with 1913; and for 1918 they both show a great increase over 1913.

Since our farming output shows a 15 per cent gain in 1919 over 1913, and our main manufacturing and mineral industries show no loss, it follows that the average gain for all commodities is about half of 15 per cent, or 7.5 per cent, which is fully equal to our gain in population during the last five years.

In the face of such facts, the argument that high prices in 1918 and 1919 are attributable to decreased productivity in America is left without any support.

There still remains the argument that the decrease in productivity throughout the world is one of the main causes of high prices. In our May 5 issue Mr. Gillette showed that the average excess of American exports over imports was annually about 2.5 per cent of the aggregate value of our wholesale commodities prior to the world war. He showed also that for the year 1915 to 1919, that excess (or balance of trade) averaged 10 per cent annually, or 7.5 per cent in excess of the prewar normal excess. For the last five years we have shipped abroad 7.5 per cent more commodities than has been our custom in prewar years. It follows, therefore, that, so far as foreign scarcity of commodities is concerned, the effect upon our wholesale prices would be to raise them about 8 per cent. Since the average wholesale price for 1919 was 114 per cent above that for 1913, it is clear that foreign scarcity of commodities has not been a very important factor, unless it can be shown to have produced some other effect than through decreasing our available supply by 7.5 per cent. In our April 7 issue Mr. Gillette showed that the "rate of money turnover" (ratio adjusted annual bank clearings to average bank deposits) had increased about 30 per cent for 1919 over that for 1913. This increase is one of the psychological effects upon business as a result of the war, but it can not be entirely attributed to scarcity of commodties in foreign countries. A great increase in the per capita currency occurred, and this alone would suffice to create a rising market, which would stimulate business activity and lead to a more rapid rate of money turnover, and correspondingly higher average commodity prices.

The daily newspapers are doing incalculable harm in their propaganda relative to "profiteering," "extravagance" and "reduced output" as the main causes of high prices. Not one of these three has had any effect whatever on average prices of commodities. It is true that cotton production has decreased greatly since 1913, and that that decrease has raised the price of textiles, but, on the other hand almost every other farm product has increased, so that, in the aggregate, the total farm production is 15 per cent greater than in 1913. It is true that extravagance has raised the price of clothing, but it has correspondingly depressed the prices of other things—building materials, for example. The diversion of money from one class of things to another affects the prices of those classes, but has no effect on average prices.

Listening to the editorials on "profiteering" one might infer that prior to the war merchants and manufacturers were given to the practice of rendering service with little or no profit; and that the war had somehow greatly changed either their natures or their opportunities. The savages who tom-tom the sun during an eclipse are not less ignorant of astronomy than are the "profiteer" editors ignorant of economics. Not only is this ignorance pitiful, but it is reprehensible; for it is resulting in a public feeling against merchants and manufacturers in general. It is unjustly arraying all classes against them—and at a time when class feeling is easily aroused.

A Great Opportunity for Engineers to Guide the Public

Last week the railroad brotherhoods presented data to the Railroad Labor Board to show that the general level of prices would not be raised by granting increased wages to railroad employes. Incidentally they attempted to prove that enormous profits of manufacturers and middlemen are the underlying reason for high prices.

In similar vein Herbert F. Baker, president of the Farmers' National Council, says that the present conditions "require drastic treatment of the predatory interests who have been mulcting the American people and have nearly succeeded in making agriculture a business to be avoided like the plague."

From every quarter issue charges against alleged profiteers. The farmer is receiving more than twice as high prices for his produce as before the war, yet he knows that his profits secure for him little if any more commodities than he had six years ago. The textile manufacturer who pays 35 ct. a pound for cotton and more than double the prewar rates of wages is equally certain that his larger annual money profits buy no more necessities or luxuries than before the war. The retail merchant who buys from the manufacturer who buys from the farmer is likewise certain that he is no better off than he was in 1913 or 1914. The employes of the farmer, of the manufacturer and of the merchant also are certain that they are no better off in spite of doubled wages and salaries. Yet every class of producer is positive that some other class is taking unfair advantage and charging too much. Have all gone suddenly crazy?

Is it not clear that when each class is accusing every other class of selfish seizure of an unjust portion of the total income, there is strong probability that no class is getting appreciably more than its normal share? Is it not even clearer that the ills flowing from attempts to readjust ourselves to the new scale of higher prices are not ills that our fellow men are intentionally imposing upon us? Are we not all in one great stew of trouble for which no single class is responsible? When it is generally realized that this is the case class attacks upon one another will cease, and attention will be directed to the real causes of high prices. Then it will be seen that those causes are all impersonal, as impersonal as a conflagration; but, like a conflagration, subject to control by human effort. At present the nations of the world are like a city mob seeking to find the man that started the fire, instead of directing their energies to extinguishing it. One group is wildly gesticulating at another group, charging it with incendiarism. The farmers call the manufacturers and merchants "predatory thieves." The manufacturers call their employes a band of lazy rogues The employes shout back the epithet "thieving profiteers." And all the time the fire burns merrily on.

Now the simple truth of the matter is that present high prices in America are not the result of high wages or of profiteering, or of reduced productivity of workmen. As a nation our per capita productivity is as great as it was before the war. This is shown conclusively in another editorial article in this issue.

Every one that has studied economics carefully knows that prices in a given country will so adjust themselves that the total annual supply of commodities will be exchanged for the total annual income of the people of that country.

Wages, salaries, rents, interest, commissions and profits are the six broad heads under which total income is distributed. So far as the effect upon average commodity prices is concerned, it makes not a particle of difference whether 75 per cent or whether 10 per cent of the total income goes to wages and salaries, provided that a change in this percentage has no effect upon the productivity of the workers. To take an extreme illustration, suppose that all the present wage and salary workers were slaves, and that they constituted 90 per cent of the population. Then the remaining 10 per cent would receive and disburse the entire income. In that case, if the total money in circulation and its rate of annual turnover were the same as today, and if the total annual production of commodities and the number of times the commodities changed hands in the course of trade were the same, the average price of the commodities would be just what the average price now is—no more, no less.

Comparatively few men have studied economics in a nation-wide way; that is, political economics. Hence the mass of error that we read in our daily papers, whether it be in editorials on the high cost of living, or in the utterances of bank presidents, or in resolutions of chambers of commerce, or in the statements of witnesses before wage tribunals, or in the proposed platforms of political parties. Never in a single period in the history of this country has a greater mass of ignorance been put into type than has been the case during the last six months. Almost every one feels competent to express an opinion as to the cause of high prices, yet not one in a thousand has qualified himself by study of this subject to have any opinion at all.

As we have repeatedly said, there is no class of men better qualified to speak authoritatively on economics than are engineers. Theirs has been the training in cost analysis, valuation and all the fundamentals of applied economics. Theirs is the scientific attitude, the impersonal attitude toward facts. Theirs should be the voice at this juncture to cry halt upon the rantings of demagogues and the vaporings of ignoramuses. Let the engineers of this country rise to the occasion, and help the people see the truth.

The First Waterworks and First Pumping Plant in Pennsylvania

According to a recently issued Water Resources Inventory Report of the State Water Supply Commission of Pennsylvania, the first water works system operated in that state was built by a Mr. Schaeffer about 1732 to supply Schaefferstown, Lebanon County, now an incorporated village, having a population of about 1,000. The works are now owned by the Schaefferstown Water Co., incorporated by special act of the Legislature in 1845. The system was willed to the citizens, each property owner on the main street to be a stockholder, and as such to pay annually 10 ct. for each member of the family; others, not stockholders, to pay 20 ct. per head per annum. There are no dividends, operation and maintenance being provided for from the funds collected. The water from a nearby spring is piped into large troughs on the main street.

The first water works pumping plant in Pennsylvania was at Bethlehem, Northampton County, constructed in 1754 by Hans Christopher Christiansen, water from a spring rising near Monocacy Creek being pumped by waterpower into a wooden distributing tank. The pump was of lignum-vitae, with a 5-in. cylinder.

The first steam pumping plant in Pennsylvania was installed in Philadelphia in 1801, water being forced from the Schuylkill River at the foot of Chestnut St. to the site of the present City Hall, where a secondary pumping station and elevated tanks effected the distribution. The earliest water company incorporated in Pennsylvania was the "Water Pipes of Aaronsburg," by special act of the Legislature, March 25, 1809, for supplying Aaronsburg village, Center County. The second and oldest incorporated water company now in operation is the York Water Co., chartered Feb. 8, 1816, for supplying the city of York.

Convention of Federal Government Engineers.—Engineers employed by the Federal Government will assemble in Washington on May 22 at the first convention of the Federal Department of the American Association of Engineers. The convention will elect an advisory council for the department, determine a plan to district the country for departmental work, and consider legislation now before Congress.

The Highway Construction Problem

To the Editor: Reading between the lines of recent articles in the technical papers and news matter in the daily press will but again emphasize the importance of conserving everything of value in our present streets and roads with a view toward giving the taxpayer and the public real value for the public monies to be expended in the gigantic programs now under consideration in all sections of the country.

Under date of April 24, 1920, Capt. F. S. Greene, State Highway Commissioner of New York, announces that no further new projects will be undertaken at present for the following reasons:

1. Shortage and high cost of labor.
2. Shortage of railway cars and the uncertainty of transportation.
3. Lack of competition in bidding.
4. Seemingly unjustifiable advance in cost of materials
5. Commercial quarries restricting output and in some instances shutting down.
6. Necessity of assuring by utilizing labor which would otherwise be directed to New York, the completion of the maintenance program.
7. The obligation of the state to protect existing contracts from labor shortage by not offering new work.

Illinois, Wisconsin and other states have also shut down on new work, giving one or more of the reasons before cited for their action.

In some states recent bids have been as much as $80,000 to $90,000 a mile on the only type of pavement specified by the state commission. In other states many needed road improvements are at present held up as the existing laws authorize the issue of 5 per cent bonds only, and which must be sold at par.

Many mistakes are being made in not adopting types of roadways involving the use of materials that can be used most economically in the location of the proposed project.

It is wrong to consider the use of a material where rail transportation and hauling is out of proportion to the cost of the material. It is folly to think of using a standard specification for various states, and even in the same state requirements may and will vary at different localities.

It is time that the public calls a halt on these state officials who thus calmly assume that there is but one standard type of road construction and that if conditions are not opportune for that type of road, work will be suspended.

Too much stress is often laid on the requirements for a rigid base, where under certain conditions a flexible base could be had at lesser cost and where local material would result in economy and an equally as good type of construction.

The public should demand that the officials give careful consideration to every type after due investigation of:

1. Underlying soil conditions.
2. Drainage.
3. Local materials available.
4. Present value of the road as a part of the new construction.
5. Prospective traffic.

So that every dollar available may be used to construct the most miles with due regard to:

1. Initial cost.
2. Durability.
3. Deterioration (maintenance).
4. Relation to maintenance and operating cost of motor vehicles.

Highway engineering is not railroad engineering, but in too many instances the layout of blue prints presents a beautiful alignment with carefully plotted railroad curves with all their required functions and with properly balanced cuts and fills to construct which will entirely destroy the stable and well settled roadbed.

The suspension of new work on account of the excessive cost of one certain type of construction and the tedious alleged refinement of preliminary and location surveys will not solve our problems nor give the much desired and demanded miles of good, hard surfaced roads.

Even with today's excessive costs of labor and material, I estimate the following as typical bidding prices on asphalt construction laid on a road which in the past has been built of material of real supporting value, based on a mile of 18-ft. road:

	Maximum. Per sq. yd.	Maximum. Per mile.	Minimum. Per sq. yd.	Minimum. Per mile.
in asphalt surface	$2.50	$26,400	$1.75	$18,480
Preparing macadam or other base	.30	3,168	.10	1,056
Other items	1.00	10,560	.10	1,056
		$40,128		$20,590

Average per mile, $30,360.

New York. HENRY W. WILSON.

Life of Cast Iron Pipe in Philadelphia

Interesting information on the life and early experiences in using cast iron pipe is given by Mr. Carleton E. Davis, Chief Bureau of Water of Philadelphia, in a recent issue of the Journal of the American Water Works Association. We quote as follows:

The first cast iron water pipe in Philadelphia was laid in 1817. It was flange pipe, imported from England. It was in continuous service until 1914, a period of 97 years, when it was replaced by larger pipes in anticipation of street repavement. It was in good condition when taken up and had evidently by no means approached the limit of its useful life, except through obsolescence. Soon after it was laid a transition from flange to bell-and-spigot pipe occurred which is discussed in some reports of that time as follows:

> In their last report the Committee stated that they had written to London for information and had ordered a parcel of various size pipes fitted in a manner which experience had pointed out as best, and they have through the diligence and care of an engineer of the first respectability obtained some very useful information contained in two reports herewith submitted, and a number of pipes constructed upon such principles as will insure strength and prevent leaks at joints, and the Committee are decidedly of the opinion that they can be laid down at first cost at as low a price per foot as wooden pipes of the same diameter. (Report of Watering Committee, Nov. 11, 1818.)
>
> Under every consideration perhaps it is well that the 14-in. iron main had not been put down as the experienced deficiency of water proved that it would have been too small, its area being 153 in. and rather less than the six ranges of wooden pipes now laid; and the method at that time in use of putting iron pipes together with flanch joints would in all probability have defeated the object of the leakage in that sort of pipes. The same inconvenience under which we now labor took place at the New River Water Works in London; and although they had 50 mains of 7-in. bore, still for want of a sufficiency of water they were compelled to abandon them and substitute large iron mains some of which were 30 in. diameter; they are cast with the common spigot and faucet joints. (Report to the Watering Committee late in 1818 by Frederic Graff, Superintendent of the Water Works, who later became the fifteenth president of the American Society of Civil Engineers.)

Five years later there was considerable criticism of the Committee for using imported pipe and it issued a statement to the effect that the greater part of the pipe already laid or on hand was made in the United States and none was imported when supplies could be obtained here except as samples for the benefit of American manufacturers. In 1823 the Committee reported the following details of the pipe and its use:

> The straight pipes are made in lengths of 9 ft. with what are called spigot and faucet joints; other pipes of a circular form, to pass round corners, are made of different lengths, as may be required, with easy turns, by which it is obvious the passage of water is much facilitated.
>
> The laying of the pipes is very easy, care being taken to keep them firm in their bed—the hub, or large end of one, laps about 4 to 6 in. over the small end of the other, leaving a space of from ¼ to ½ in. all around, which is first caulked in with a ring of plaited hemp to prevent the lead running into the pipes; then a pair of nippers with a joint in the lower part, to fit all around the pipes, and having an opening on top for the lead, and another for the escape of the air, is affixed next to the opening on the outer part of the pipe, so as to prevent the lead coming out in front, which is further secured by a ring of clay, outside of the nippers, and formed into a cap at top, into which melted lead is poured, forming a ring of lead 3 or 4 in. in depth. When the lead is cold the clay and nippers are removed and it is then upset with a hammer and chisel, which completes the joint.

A line of this old pipe which was laid in 1827 was removed in 1915 during subway construction. It was in excellent condition after 88 years of service, but was not relaid because a main of larger capacity was desirable. Several hundred feet of 30-in. pipe laid in 1850 was taken up during 1918 to facilitate parkway construction and found to be in such satisfactory condition that after being cleaned they were relaid.

Method of Repairing Water Tunnel With Cement Gun

A 120-ft. section of defective pressure tunnel on the main supply line of the Water Department of the city of Tacoma, Wash., has recently been repaired with steel reinforcement and gunite in a manner and under conditions which render the work of particular interest. The improvement involves many interesting details which should be of value to others having similar work or operating a cement gun under conditions of extreme humidity.

Design of Conduit and History of Construction.—The tunnel is about 360 ft. long, with plain concrete walls from 18 in. to 24 in. thick, and of a section shown in the accompanying drawing. It is located about ½ mile below the intake, and carries the supply line through a narrow rock and shale point to the bank of the Green River, which is crossed by a 250-ft. bridge carrying an open flume. The original plan for the project, however, provided for passage of the river by tunnel instead of by bridge, and was changed only after excavation had reached the line of the river's edge. When the grade was raised the excavated position below grade was filled with loose rock for a distance of 40 or 50 ft. from the outlet, and upon this rested the unreinforced concrete lining of the completed conduit. The outlet was then at about the level of normal river stage, and in order to secure a height sufficient for the river crossing, a concrete well 12 ft. square was constructed as a tunnel terminal and a monolithic part of the bridge abutment. The depth of this well is 29 ft. and the proper pressure head is maintained within it by control from a spillway above. The defective portion extends from the outlet at the well, for a distance of 120 ft. back in the tunnel, and is on an 8 per cent or 9 per cent grade.

Origin and Character of Defects.—Very soon after the works were put into operation in 1912 leakage began to show on the surface of the ground. Small at first, it developed steadily until at the beginning of the present year it was estimated at 10 cu. ft. per second. In spite of a condition of municipal finance requiring every possible saving, any further postponement of repairs was believed to involve too great a hazard. Various plans for handling the situation were given careful attention, with the result that the one here described was chosen as best meeting all essential requirements.

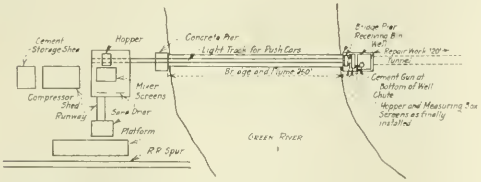
When water was turned off and the tunnel entered for inspection, the defects were found to be substantially as had been expected. Concrete for the entire 120 ft. at the lower end was defective, being conspicuously porous. Beginning at a point 25 ft. inside the tunnel, and continuing for a distance of slightly more than 40 ft. were longitudinal cracks, some as much as 1½ in. wide. At their upper end these cracks were only two in number—one at each roof shoulder. Within a few feet, however, others developed, until there were six in the roof and two at the junctions of sidewalls and floor. There were also four transverse cracks, and in places the whole roof had been raised by the pressure.

While the upper section of tunnel was in solid rock, the 120-ft. defective portion was in shale and a conglomerate of hard clay and gravel; and it appears that the leakage through the porous concrete had caused a washing out of supporting material resulting in the cracks and roof-lifting.

Requirements of Water Supply, Program of Work, Limitations, Etc.—Some 26 miles below the leaky section is located the McMillan reservoir with capacity of 110,000,000 gal. This amount, supported by an auxiliary supply pumped from wells, can carry the city's requirements for somewhat more than 6 days. This period was accordingly set as the maximum time for which the supply could be shut off. But of the 6 days, only four were available for actual repair work, the rest of the time being consumed about as follows: Twelve hours to shut off the supply at the headworks and drain the line without danger of collapse; 12 hours more to allow seepage to run back from ground through cracks in tunnel lining; 12 hours after depositing of last concrete until turning on water; 12 hours from turning on of water until there is full discharge into McMillan reservoir.

To fill the reservoir requires about 1 days' continuous flow, so that it might be expected that repair work could be divided into stages separated by 6-day periods, which would be sufficient for all operations of emptying and refilling the line and filling the reservoir. However, the position of the tunnel outlet and blow-off valve at normal river level prevents drainage if the river is above this stage. The contingency of a rise occurred immediately following the second period of repair operations in February, and for more than two weeks high water prevented the city from resuming work. About the middle of March, however, there was sufficient subsidence to permit of draining the tunnel, and the third period was accordingly carried through. Another rise delayed the fourth and final period.

Design and Procedure of Repair Work.—Prior to the first opening of the tunnel a cement gun, air compressor, and pressure grouting tank, with accessories and materials were installed at the site. As soon as inspection had shown the character of defects, the broken sections of lining were timbered for safety. Six 20-ton jacks were used in an attempt to test the stability of the various broken pieces, with the result that only one small section was moved. This lead to the belief that the lining might be repaired as it stood, and work was accordingly undertaken with that end in view.



Sketch Showing General Arrangement of Plant for Repairing Tunnel.

The cracks were cut out with air tools to varying widths up to 18 in.; nipples were inserted, wedged and grouted in place, and grout forced in from the tank until the appearance of the grout at other nipples and on the surface of the concrete indicated that the voids were filled. The oozing of grout through the concrete gave further evidence of its excessive porosity. The work was almost completed when the time limit of the shut-down arrived. In spite of the expectation that the grouting would prove an effective remedy, when water was again turned into the tunnel, and a pressure of about 80 per cent normal was reached, leakage appeared on the hillside, and it was decided that more elaborate repairs must be made.

A 6-ft. diameter reinforced concrete pipe was selected as best meeting the requirements of safety, speedy construction and reasonable cost. While such a design would greatly reduce the conduit section at this point, computation showed that a ¾-in. raise in level at the intake would maintain the full flow for which the system was designed. The raise in water level will be provided by an inexpensive flash-board whenever it may become necessary.

The design provided for concrete blocks to fill the greater part of the space at the sides and corners of the tunnel; the reinforcement to be set on the center line, and the remainder of the section filled with gunite in layers.

Reinforcement consisted of a hooping of ⅜-in. square bars spaced 4 in. on centers, and made up in 5-ft. sections on ⅜-in. longitudinal bars spaced about 30 in. The sections were all prepared in advance before the tunnel was drained the second time. For the upper end, where the repair section joins the original, a special conical section was provided to make the transition.

Procedure was as follows: When the tunnel was entered after the second drainage, cracks were found to have again developed in a few places in the old concrete on lines approximately parallel to the original cracks. These were repaired in the same manner as were the first ones.

A canvas windshield was constructed at the upper end of the repair work, thereby stopping the heavy draft of air and making it possible to warm the repair section by means of a stove. As there was still a small flow of water from the line further back, a concrete dike was laid across the bottom at this same point, and a 2-in. pipe installed from there to the blow-off valve in the well.

The necessity of speed led to the simultaneous carrying out of as many parts of the work as possible. The precast concrete blocks, the largest of which weighed about 250 lb., were placed dry and coated with mortar from the cement gun to a depth of from 6 to 8 in. This work was completed for a distance of about 80 ft. from the upper end and partially completed for the rest of the distance. It occupied about 1½ days.

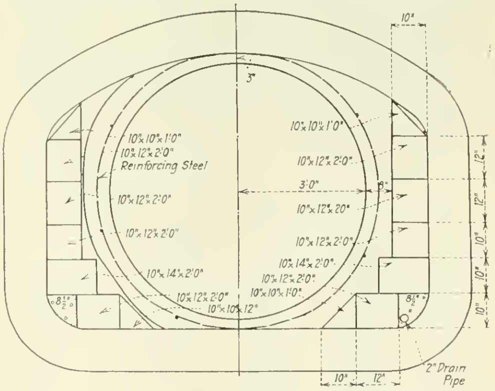
The rather large thickness of "gunite" was deposited to give a maximum assurance of withstanding the water pressure which would be put upon it within 24 hours from the time it was placed. It is appropriate to state here that when the tunnel was drained the next time, the gunite was all found in perfect condition. Seepage was still progressing from some of the cracks when they were reached by the cementing crew. Most of these cases were closed by the discharge of cement from the nozzle held not more than 2 ft. away. In a few instances nipples were inserted to relieve the pressure.

Following these operations, the reinforcement was placed, about 4 hours being required therefor. Concreting was then resumed, and continued up to within 12 hours of the time that water was to be again turned into the tunnel. At the end of the period there stood completed about 70 per cent of concrete block filling, 60 per cent of reinforced concrete, and 25 per cent of cement gun work. The water supply was shut off for 6 days, and actual repair work was in progress for less than four days. Considerable delay resulted from trouble with the air compressor and other causes.

The next succeeding period of work was of equal duration. During it the last of the concrete blocks and reinforcement were placed and cement gun work was about 65 per cent completed Windshield and stove were installed as in the first case.

General Plant Layout and Operation.—The accompanying sketch shows the general arrangement of plant.

Sand was usually in a saturated condition when received. No suitable drier being available, one was constructed of materials which were on hand on a design prepared by the superintendent. After thorough drying, the sand was wheeled to the mixer shed and put through screens of 6 meshes per inch. The cement and sand were dry-mixed and discharged through a hopper into light cars, which were then pushed across the bridge to a hopper mounted at the top of the well, and which delivered the material to a measuring box from which it was turned directly into a chute to the cement gun on signal by the operator. The water and compressed air lines were laid beside the track across the bridge to the gun. The screening of sand in the cement shed was found unsatisfactory, and while the work was in progress screens were moved to a place on the pier at the tunnel end, and the entire mix was screened there.



Sketch Showing Concrete Blocks in Position for Repairs on Tunnel.

Plant Details and Operating Experiences.—The drier was as stated, made locally, and proved entirely satisfactory. The mixer was a "Wonder" of 3 cu. ft. batch capacity. It was gasoline driven as was the compressor. The cement gun was an N1.

The air pipe from compressor to gun was 2 in. diameter and a little more than 300 ft. in length. The material hose from gun to work was 1½ in., and the water hose ½ in. Working pressure was 65 lb. at the compressor.

Gunite was placed at the rate of about 1 cu. yd. per hour. This included lost time, of which there was a good deal, and it was considered that under favorable conditions this rate could be greatly increased.

Weather was rainy during most of the work, and some trouble was caused by water getting into the cement gun from condensation in the compressor and air line. Mr. W. A. Kunigk, superintendent of the Tacoma Water Department, states that in future cement gun work under conditions of high humidity he will install an air drier at the compressor intake, and will also put a trap in the air line to intercept condensation.

About ½ plastering sand and ½ ordinary concrete sand were used. The cement was ordinary Portland. Mixtures varied from 1:2½ to 1:3, depending on the coarseness of the sand. A 4-mesh sieve was tried but was found less satisfactory than the 6-mesh because of the rebound of the coarser pebbles on overhead work. The most satisfactory cement gun charge was found by trial to be about 0.7 cu. ft.

Operations were begun with an absolutely dry mixture, but this resulted in cement blowing through the sand at the nozzle and producing so much dust in the tunnel that the men were scarcely able to work. A mixture containing from 5 per cent to 8 per cent by weight of moisture was found to almost entirely obviate this difficulty, and believed to produce results even better than the absolutely dry. These moistures did not produce any clogging in the line. The gunite was built up in from 1-in. to 2-in. layers, the thinner coatings being on the overhead work. Each layer was allowed to set for from ½ hour to 1 hour before the next application.

The entire working force was composed of green men, but under instruction from Superintendent Kunigk no particular difficulties resulted from this cause. The regular working organization was as follows:

1 man operating drier.
2 men handling materials, operating mixer and miscellaneous work.
1 man wheeling materials from mixer to hopper at gun.
1 man screening mixture and feeding gun (at times this man had a helper).
1 man operating gun.
1 man operating nozzle.
1 man moving material, hose and hose supports; placing lights as needed; and sweeping gunite from reinforcement until back spaces were filled.

8 men. Total cementing crew.

Other operations (placing concrete blocks, reinforcement, etc.) required from 4 to 8 additional men.

It is estimated that the entire cost of the repair job will be less than $8,000. The work has been carried out under the direction of Mr. W. A. Kunigk, Superintendent of the Tacoma Water Department.

Chlorination and "Chemical Taste" and "Medicinal Odor" of Water.—Many water works operators have noticed a close psychological connection between the thought that water was being chemically treated and a well-defined perception of it by some people. Commenting on this, Mr. Caleb Mills Saville, Chief Engineer and Manager of the Water Department of Hartford, Conn., in his 1919 report says: "Complaints are of record in most places where chlorine gas has been used and in one instance in the case of several districts of a city supplied from different sources, only one of which was chlorinated, the largest number of complaints of odor and taste came from one of the districts which was not supplied with chlorinated water. With the amount of chlorine gas used as a sterilizing agent with Hartford water and a consumption of 1 gal. of water per day per individual, it has been estimated that it would require nearly 3,900 years for an individual to receive into his system the amount of free chlorine given as a medicinal dose in cases of typhoid fever."

How Irrigation Increases Crop Yields.—What irrigation does for yield per acre is expressed in the comparative results of an investigation made by the Colorado Crop Reporting Service. Corn production in 1919 in that state on irrigated land was 30.6 bu. per acre and on nonirrigated land 15.2 bu.; winter wheat, 24.7 and 9.3 bu., respectively; spring wheat, 22.8 and 7.4 bl.; oats, 37.0 and 15.2 bu.; barley, 30.8 and 12.5 bu.; rye, 15.5 and 8.6 bu.; and potatoes, 155 and 34 bu.

Hydraulic Fill Dams

The hydraulic method of dam construction has great advantages, but too many dams built by it have failed. As often built, the center of the dam is composed of a clay core completely water-tight but very wet as a result of the method of construction, and so completely water-tight that it is incapable of permitting its own drainage. This soft core in the center of the dam exerts the pressure of a liquid of high specific gravity upon the toes and tends to push them out. This pressure seems to have been responsible for most of the failures of hydraulic-fill dams. The method of placing the core commonly used results in an exceedingly fine-grained material, desirable from the standpoint of a water-tight dam; but it may be that extreme tightness is secured at the expense of stability. To use the hydraulic method of dam construction successfully, it is necessary either to increase the toes until they are large and heavy enough successfully to resist the full fluid pressure of the core, or else to handle the core material so that the finest particles are wasted, leaving only the larger ones, and in that way increasing the grain size to a point where drainage can be secured, while on the other hand remaining sufficiently impervious for practical purposes.

The above conclusions are quoted from a paper[*] presented May 5 before the American Society of Civil Engineers by Allen Hazen, Consulting Engineer, New York City. An abstract of the paper follows:

The hydraulic method is certain to have an important place in future dam construction. It has two fundamental advantages: First, in sorting out the fine particles and placing them in the center of the dam, thus insuring complete water tightness; and, second, in the use of power in place of muscle to the greatest extent, so that the labor and animal cost of construction is reduced to a minimum.

On the other hand, several hydraulic dams have not proved to be stable Failures, usually during construction, have caused great losses, and their occurrences has been discouraging.

There may have been more than one cause of failure, but one cause has certainly predominated. In this interior of the dams there have been masses of clay and other fine-grained material, that have not consolidated to the point of stability.

Instead of forming an integral part of a solid dam, these have remained in almost liquid form, dividing the dams and tending to disrupt them. In this respect, hydraulic fill dams are on a different basis from other earth dams. If the hydraulic method is to be successfully used, this element of weakness must be eliminated.

There seems to be two promising ways of eliminating it. The first and most natural one is to increase the size of the dam until the solid parts forming the toes are amply strong to resist the full fluid pressure of the unstable core. The second consists in selecting material and handling it in a way to secure drainage and consolidation of the core, so that the whole dam will act as one solid mass.

If core material can be fully drained and consolidated, there is no reason why a dam built by the hydraulic method on a section that is suitable for an earth dam built dry should not be safe. If drainage and consolidation of the core is not secured, however, safety can only be reached by making each toe large enough to stand the full pressure of the liquid core, and in that case, in order to be safe, a dam built by the hydraulic method must have flatter slopes and a larger section than is otherwise needed for an earth dam.

The number of failures with hydraulic-fill dams growing out of this fundamental condition of fluid cores and inadequate toes has been such as to make it clear that this condition of instability has not been recognized in the designs. Enough experience has been gained so that a better analysis may be made. To insure success with future hydraulic dams, this analysis must be thorough. It is the writer's thought that it will be possible to make it in a way to secure as high a degree of safety in hydraulic-fill dams as is required and is customary in other engineering structures.

Character of Core Material.—The first point to be considered is that, in many or perhaps most hydraulic-fill dams, the core material is so fine in grain size that it is incapable of drainage. By that is meant that it is incapable of drainage within a reasonable length of time. The lower parts of the core do not become stable before the upper parts are placed upon them.

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[*] Hydraulic Fill Dams, Proceedings Am. Soc. C. E. Vol. XLVI, No. 4, pp. 525-557.

In general, all the material placed in hydraulic-fill dams may be divided into two classes, namely, toe material and core material. The core material may be defined as that part of the dam deposited from water in the central pool. In the writer's experience, core material is homogeneous. At any level there is no appreciable difference in grain size between the middle of the core and its farthest extremities.

The principles determining the size of particles deposited in the core, or not deposited, are the same as the ones that apply in a sedimentation basin of a water works plant. The larger the area of the pool in proportion to the quantity of water that goes through it, the more complete will be the subsidence, and the smaller will be the limit of size of particles retained.

Most hydraulic-fill dams have been built with good-sized pools in the center during construction (Fig. 1), in which sedimentation has been fairly complete. The writer has examined samples of the core materials from a number of dams. The samples are rather surprisingly alike in grain size. They ordinarily contain particles in large quantities down to a limit between 0.001 and 0.002 mm. (or sometimes 0.003 mm) in diameter. Generally speaking, all smaller particles have been carried away by the escaping water and have not remained in the core.

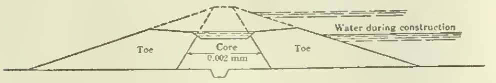


Fig. 1—Typical Section of Hydraulic Fill Dam During Construction.

Core material as a matter of observation, consists of particles from this size up to the size of the smallest particles retained in the toes. In a general way, this size may be taken as 0.03 mm., or 10 to 15 times as great as the limit of size of particles that are retained in the core. Speaking of core materials in the terms that are used in describing sand, it may be said that the effective size of core material is ordinarily about 0.002 mm.

The reason why core material does not drain is clear. It seals itself up and becomes practically water-tight. With the dimensions existing in dams that have been built, assuming that the laws of flow known to apply to the finest sands apply also to the still finer materials, it will take years for the excess of moisture to drain out, as it must do before the solidification of the material is possible. As a practical proposition, drainage is not possible with such fine materials. By that is meant such prompt and complete drainage as will result in solidification during the construction of the dam.

Construction records and samples show approximately what happens. Core material of the fineness already described goes down first in the form of soft mud in which the voids filled with water are at least 70 per cent of the total volume. Such mud is very soft.

The percentage of voids furnishes, on the whole, the best index of consolidation and stability. In itself, it is not an adequate basis of comparison, because different kinds of core material may have different degrees of stiffness with the same percentage of voids; but, notwithstanding this difference, the percentage of voids is the best index of consolidation so far available.

One of the best field methods of testing the consolidation of core material has been to find the depth to which a 1½-in. pipe could be forced into it by two men. This method of testing has been used in several dams. It has been possible to co-ordinate the penetration so found with records of the percentage of voids. In a general way, penetration by 1½-in. pipe pushed down by two strong men extends to the point where the voids are about 50 per cent. In other words, the 50 per cent material is so stiff that it can no longer be penetrated to any considerable depth by this method.

Tests of material by letting down cannon balls, etc., are less searching. The penetration does not go as far.

Core material consolidated to 35 per cent of voids would form the strongest and most stable kind of an earth dam. No large toes would be required to contain it, for on any reasonable slope it would be stable by itself. Such consolidation, however, as far as is known, is reached only by complete drying. Unfortunately, drying cannot be applied to the core of a large dam.

Without attempting precision of statement, it is the writer's judgment that if core material like that at Calaveras could be consolidated to 40 per cent of voids, it would be sufficiently stable to do its share toward resisting the pressures that come upon the dam without tending to disruption. Perhaps this degree of stability would be reached before consolidation had proceeded as far as 40 per cent of voids. There is a middle ground of uncertainty. Material with 50 per cent of voids is still unstable; and between this limit and 40 per cent, one cannot be certain just where to draw the line.

It is the writer's thought that the best method of investigating consolidation and stability is by making borings. There are difficulties, for boring usually involves stopping the sluicing of material while the holes are being put down; but it does lead to more definite results. Borings can be driven and samples taken from the bottom of the borings for physical inspection and for determination of the percentage of voids.

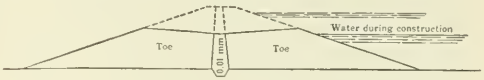


Fig. 2—Proposed Section with Narrow Coarse-Granite Core.

Determination of Percentage of Voids.—This is a very simple matter, but experience shows that it is easy to go wrong, and for that reason a brief statement of methods that have been found suitable will be given.

The samples taken from the bottom of test borings are saturated with water. A determination of water content, therefore, can be made a measure of voids. This procedure is sound so far and only so far as the voids are completely filled with water. A useful check can be obtained from the specific gravity of the moist material.

The specific gravity of the solid particles of core material may be taken as 2.65. It may be that in some locations other specific gravities will be found, but in the writer's experience, actual values differ little from this mean value.

In determining the specific gravity of these exceedingly small particles, the most careful manipulation is required to get all the air out of the dry material. Methods similar to those used for determining the specific gravity of Portland cement are appropriate, but water can be used.

A table can be made showing the weight of the solid particles, the weight of water, the percentage of water by weight, and the specific gravity of core material containing various percentages of voids. Table I, in convenient and

TABLE I—SATURATED CLAY.*

Specific Gravity of Solid Particles, 2.65.

Percentage of voids.	Percentage of water by weight.	Specific gravity. Wet.	Weight per cubic foot. Wet.	Weight per cubic foot. Dry.
40	20.1	1.990	124.2	99.2
41	20.8	1.974	123.1	97.5
42	21.5	1.957	122.1	95.9
43	22.2	1.940	121.1	94.2
44	22.9	1.924	120.0	92.6
45	23.6	1.908	119.0	91.0
46	24.3	1.891	118.0	89.3
47	25.0	1.874	117.0	87.6
48	25.8	1.858	116.0	86.0
49	26.6	1.841	115.0	84.3
50	27.4	1.825	114.0	82.7
51	28.2	1.808	112.9	81.0
52	29.0	1.791	111.9	79.3
53	29.8	1.775	110.8	77.7
54	30.6	1.759	109.8	76.0
55	31.5	1.743	108.7	74.4
56	32.4	1.726	107.6	72.8
57	33.3	1.709	106.6	71.1
58	34.2	1.692	105.6	69.5
59	35.1	1.676	104.5	67.8
60	36.1	1.660	103.5	66.1
61	37.1	1.643	102.5	64.5
62	38.1	1.626	101.5	62.8
63	39.1	1.609	100.5	61.2
64	40.1	1.593	99.5	59.5
65	41.2	1.577	98.5	57.8
66	42.3	1.560	97.4	56.2
67	43.4	1.543	96.4	53.5
68	44.5	1.527	95.4	52.9
69	45.6	1.511	94.4	51.2
70	46.8	1.495	93.4	49.6

*This table is not to be used for any material that has lost water by evaporation so that the voids are not completely filled with water.

somewhat condensed form, gives these values for satuated clay.

When a sample is taken from a test boring, a portion is put in a dish and weighed. The weighed material is dried at or above the boiling point to constant weight, and the percentage of moisture computed. As even a little drying before the first weight affects the result, the samples should be weighed on the spot when first brought to the surface; to do this, portable equipment must be used. After the first weighing, samples may be taken to the office or laboratory for the completion of the process. When the percentage of moisture by weight is found, the corresponding percentage of voids is obtained from Table 1.

As a check, the specific gravity of another part of the sample is determined. This is obtained by putting a weighed portion of the moist mass into a graduated cylinder partly filled with water and noting the increase in water level. The specific gravity is the ratio between the weight of material added and the weight of the water that corresponds to the increase in level, and so to the volume of material placed in the cylinder. With this specific gravity determined, Table I indicates the percentage of voids.

The percentage of voids determined by the two methods with good manipulation should check within 1 or 2 per cent. if it does not there is something wrong and the error must be found and eliminated.

To determine the weight of the coarse and hard toe material, no better method has been found than to make an excavation accurately to a dimension of 1 cu. yd., or other convenient size, and to weigh the excavated material on platform scales. Percentages of moisture vary, and the weight of dry material affords the best basis of comparison. An average sample of material on the scales is taken for determining the percentage of moisture, and the results are reduced to weight of dry material per cubic foot.

Draining Fine Material.—The writer is fully satisfied that there is no practical way of rapidly draining core material as fine in grain size as that described previously. He has considered it from a theoretical standpoint and also from the standpoint of practical experience.

After the material reaches a condition of 50 per cent of voids, 6 cu. yd. must be compressed into 5 cu. yd. of 40 per cent material by the exclusion of 1 cu. yd. of water before full stability can be counted on. This water, amounting to one-sixth of the whole volume of core material, must be expelled. The computed rate of flow through material with an effective size of 0.002 mm. is very slow. The rate depends on, and is proportional to, the hydraulic slope. With a slope of 10 per cent (which is as steep as is usually found) the computed rate of flow as a solid column of the full area of the section is 0.32 mm. daily. At this rate, 80 days are required for the water to move 1 in. and 2.6 years for it to move 1 ft. This calculation cannot be used with assurance as establishing the exact rate of flow, but it is the writer's judgment that the actual rate is as likely to be below as above the result given. It is clear that, for a large dam, complete drainage and consolidation may be a matter of many years.

From a practical standpoint, it may be recorded that a 6-in. well driven 60 ft in saturated core material having voids averaging 50 per cent, with the casing perforated freely to admit water, stood empty for weeks. Not enough water drained from this material to raise the water in the well. This may represent the effect of capillarity. With such a degree of tightness, it is clearly useless to attempt to secure consolidation by any method depending on additional drainage outlets.

Measuring Core Pressures.—An interesting method of measuring the pressures actually existing in core materials has been suggested by A. T. Goldbeck, Assoc. M. Am. Soc. C. E. By this method, small test cells are built into the core material. Some are placed with horizontal and some with vertical faces, arranged to indicate pressures on the faces during construction and afterward. Such devices are reported to have been placed in hydraulic-fill dams now building by the Miami Conservancy District. The results of observation through a certain period have already been recorded. These observations indicate, as would be expected, that the horizontal and vertical pressures are the same at first and until the material has become somewhat consolidated. Afterward, horizontal pressure increases less rapidly than vertical pressure, and the inference may be drawn that this represents solidification of the material in which the cells are placed to a point where the full horizontal pressure is no longer produced.

This is certainly an interesting method of test and one that may throw light on the conditions of core material.

Resisting the Pressure of the Core Material.—The first point to be considered is the coefficient of friction of the material in the toe, sliding either upon the foundation or upon itself. With hard, clean gravel a coefficient of 0.7 or 0.8 might reasonably be expected, although the data for establishing this coefficient are not as convincing as could be desired. No such coefficient was found, however, in accounting for the Calaveras slip. Instead, it was estimated that the weight of the material pushed forward in the upstream toe was five times as great as the pressure of core material against it. In estimating that pressure the whole height and weight of core material was included, assuming that it acted as a heavy liquid. This indicated a coefficient of friction of only 0.20. This is to be taken as an average for the whole area on which the slip occurred. It may be recorded, however, that a similar calculation for the lower toe which did not slip indicated a coefficient of 0.22. No one can tell how much more it would have held.

The Calaveras material is softer and perhaps more slippery than the hard particles of glacial drift of the eastern states; and it would not be reasonable to expect as high a coefficient of friction. It may be, also, that the coefficient of friction under such heavy pressures as are found in the lower part of a high dam will be less than under the small pressures of moderate depths.

Section of Dam Required with Core Material Considered as a Fluid.—At Calaveras, the toe material was slightly heavier per cubic foot than the core material. At San Pablo, with fragments of porous sandstone rock predominating in the toes, there was scarcely any difference. With harder material like the glacial drift of the eastern states, the toe material would be considerably heavier.

For the purpose of a first rough calculation, assume that the weights per cubic foot of toe and core material are equal, as they are at San Pablo. If a coefficient of friction of 0.5 is assumed, each toe must weigh twice as much as the pressure exerted by the core. The pressure exerted by the core is $\frac{1}{2}$ wh^2 and the weight of the toe to balance it must be wh^2. To produce this weight, a uniform outer slope of 2 to 1 will suffice. In addition, a top width equal to the maximum width of core must be used. If a factor of safety of 2 is required, the outside slope must be made 4 to 1, but in view of the records of slips in actual dams, it may well take a higher factor of safety. A slope of 5 to 1 will give a factor of safety of 2.5 and a slope of 6 to 1 will give a factor of 3. Where toe material is considerably heavier than the core, as would be the case with harder and heavier rocks, the slopes could be reduced in proportion to the increased specific gravity without reducing the factor of safety. Thus, with toe material 20 per cent heavier than core material, a slope of 1 to 5 would allow a factor of safety of 3. Very few hydraulic dams have been built with sections as large as this line of thought suggests. The Gatun Dam at Panama heads the list, and is even larger.

A great many cubic yards are involved in such a large section, but if the work is done cheaply enough per cubic yard, it may be economical to use the extra volume. Safety can be secured in this way; and it may be that this procedure is the best one to follow.

Dimensions of a Number of Dams.—To see what these slopes would call for in the way of section in comparison with earth dams that have been actually built either by the hydraulic method or as dry fill, the following comparison is made. Assuming a freeboard of one-tenth the greatest depth of water, H, and a top width of 0.25 H and uniform slopes, the cross-sections of dams in terms of the greatest depth of water would be as follows:

Slope.	Volume.
3 to 1	3.9 H^2
4 to 1	5.1 H^2
5 to 1	6.3 H^2
6 to 1	7.5 H^2

The actual dimensions of a number of dams are given in Table II.

Rock-fill dams are not included, but rock fill forms some part of a number of dams in the list. No dams holding less than 64 ft. of water are included.

The Necaxa Dam slipped, but was afterward rebuilt on the original section. The Big Meadows Dam is being raised with an enlarged section.

Increasing the Grain Size of Core Material.—The second way of increasing stability is to use core material that will consolidate more rapidly and thoroughly. There is only one way to insure this; that is to increase the grain size of the material allowed to remain in the core. With pools and water quantities actually used in the dams known to the writer, particles smaller than 0.001 mm. and perhaps up to 0.002 mm. have been wasted. Everything larger has gone into the dam.

In some cases, an effort has been made to secure completeness of deposition of these fine particles to avoid waste and to increase the yardage accounted for in the dam.

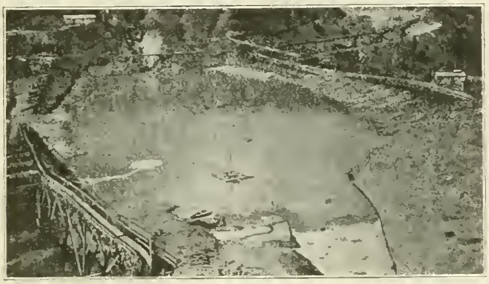


Fig. 3—San Pablo Dam, Showing Maximum Width of Central Pool.

To increase the effective size of core material, it is necessary to increase the limit of particles to be wasted. This can be done by narrowing the pool or by increasing the quantity of water passing it (see Figs. 2, 3, 4 and 5). On one occasion at San Pablo, to test this out, the toes were allowed to increase in height for a time without raising the pool. This was continued until the pool almost disappeared. Hardly more than a muddy creek remained in the middle of the dam. The core became comparatively narrow and much coarser in grain size. The effective size was increased to approximately 0.01 mm. Finer particles were all wasted. In other words, the core material was, say, five times as great in grain size. It had, therefore, 25 times as great draining capacity, and only 1/25 of the capacity to hold water by capillarity.

Material placed in this way had a much better chance of drainage; first, because the core was narrower and there was less water to be removed; second, because the water had a shorter distance to go; and third, because, other things being equal, the water would get away 25 times as fast. After a few weeks of operation in this manner, the work was stopped temporarily, which gave an opportunity to examine the deposited core material. After only a few days it became hard enough to walk on, many times more solid than ordinary core material.

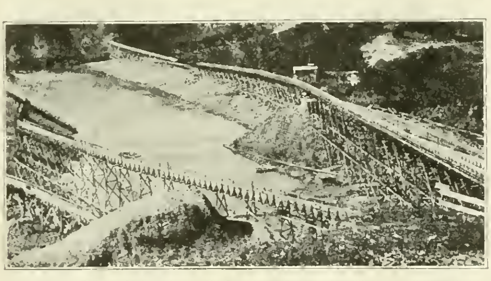


Fig. 4—San Pablo Dam, Showing Ordinary Width of Central Pool, Producing Core Material 0.002 Mm. in Size.

In one other respect this coarse-grained puddle differed from ordinary puddle. There was a small relative range in its grain sizes. The fine particles were eliminated, and the volume of puddle produced was reduced, but there was no very great change in the quantity and character of the coarser particles. These coarser particles constituted the whole mass of the coarse-grained puddle. With ordinary puddle, they were mixed with a large additional volume of fine-grained stock. The grains in the coarse-grained puddle were thus more nearly of the same size, and it followed that, other things being equal, the percentage of voids was greater. This was found to be the case in the test at San Pablo, and after the material had become hard and stable, it had a percentage of voids that would have indicated lack of stability in ordinary stock. This is an illustration of the fact that voids used as an index of stability can only be properly compared for the same kind of stock.

If this method of increasing the grain size of core material were to be followed throughout the construction of a dam, obviously there would be two results. First, a great deal of fine material would be wasted. The quantity would depend upon the quantity of such material in the stock used. In the natural course of events most of this would be deposited harmlessly upon the bottom of the reservoir. Second, a dam built in this way would be much more stable but theoretically not quite water-tight. There would be an appreciable amount of seepage through core material of this grain size.

The amount of seepage loss may be estimated approximately. Assuming that the laws of flow are the same as they are in the finest sand to which experiments have extended, it was estimated that at the San Pablo Dam if the whole core material could be made 0.01 mm. and if the rest of the dam had contributed nothing to tightness, the theoretical rate of seepage would be 280,000 gal. per day. The loss of this quantity of water would not be a serious drain upon the supply, if it adds to stability. Practically, as is known from filter experience, considering the core material as a filter, it would soon silt up and become water-tight.

As a practical proposition in dam construction, core material having a grain size of 0.01 mm. is to be accepted as sufficiently fine from the standpoint of water-tightness. This size of 0.01 mm. is not given as a precise limit. It may be that still coarser material would give sufficient tightness or that finer material would drain sufficiently. The size is mentioned because it is the size of material that was actually found possible to produce at the San Pablo Dam by reducing the size of the pool to a minimum, and because other considerations suggest that it may be suitable.

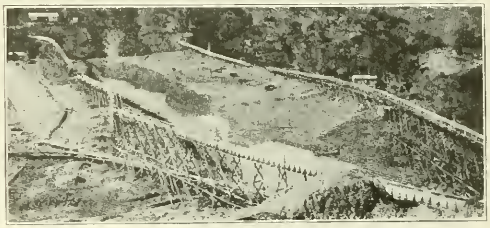


Fig. 5—San Pablo Dam, Showing Central Pool Greatly Reduced in Width for Purpose of Increasing Grain Size of Core Material. It Was Pushed to a Narrower Width Than Shown.

TABLE II—DIMENSIONS OF A NUMBER OF EARTH DAMS THAT HAVE STOOD SUCCESSFULLY.

Dam.	Height to flow line, H.	Area of section, in square feet, A.	Ratio, $\frac{A}{H^2}$	Free board.	Width, in feet. Top.	At flow line.	50 ft. below flow line.	100 ft. below flow line.	Bottom. W.	Ratio, $\frac{W}{H}$
*Gatun	78	99,200	16.30	30	100	397	1,469	...	1,990	25.5
*Big Meadows	64	24,300	5.93	20	30	160	460	...	548	8.56
*Coquitlam ..	83	38,700	5.61	15	40	145	521	...	702	8.48
*Cambria	82	31,200	4.65	13	20	98	429	...	685	8.34
Ashokan ...	90	35,400	4.37	20	34	112	400	...	650	7.23
Druid Lake..	82	27,900	4.15	5	60	90	390	...	582	7.10
San Andreas	80	26,200	4.10	5	30	58	387	...	606	7.58
*Paddy Creek	120	58,200	4.05	25	23	161	414	664	757	6.30
*Somerset ...	92	33,200	3.94	13	25	78	375	...	616	6.67
San Leandro	65	16,350	3.88	5	30	56	335	...	457	7.04
*Haiwee	75	21,600	3.85	14	20	90	340	...	465	6.20
Croton	96	33,400	3.62	24	30	126	336	...	528	5.50
Tabeaud	86	26,400	3.57	8	20	60	345	...	553	6.44
*Necaxa	164	90,800	3.35	16	54	136	386	636	954	5.81
Cold Spring.	88.5	26,200	3.34	10	20	70	320	...	512	5.79
BelleFourche	100	33,100	3.31	15	20	65	284	656	656	6.56
Lahontan ...	112	46,900	3.25	12	20	80	330	560	640	5.72
Santa Maria.	85	23,500	3.25	8	20	60	310	...	485	5.71
Pilarcitos ...	74	17 600	3.22	5	30	56	288	...	415	5.61
Morris	90	25 700	3.18	9	20	60	309	...	502	5.58
BordenBrook	64	12,700	3.10	7	24	49	280	...	337	5.27
Honey Lake.	90	25,000	3.08	6	20	50	300	...	500	5.56
Goose Creek	137.5	54,900	2.90	7	16	54	304	554	741	5.39

*Hydraulic fill, wholly or in large part.

The question remains as to whether a dam in which the pool and water quantities were so adjusted as to hold the effective size of core material at 0.01 mm., or at some other selected limit, and in which the core material was never permitted to become very wide, would consolidate itself as the dam increased in height to an extent that would eliminate lateral pressure of core material.

It is the writer's, idea that a dam built in this way would certainly be more stable and safer than one in which the core material contained an additional quantity of finer particles.

This thought is similar to an idea expressed by D. C. Henny, M. Am. Soc. C. E., who stated:

> Probably the nearest approach to a perfect core of great thickness which can be hydraulicked, is one composed of fine sandy silt, such as is generally found in the arid West, having little cohesiveness, good self-drainage qualities, becoming hard and solid after a short time, and yet being, if not perfectly, at least practically water-tight.

Mr. Henny's description may be taken as an accurate description of the writer's idea of 0.01-mm. material. It certainly does not apply to 0.002-mm. material. Mr. Henny's other propositions in regard to fine core material such as is ordinarily used, are believed to be well founded.

The Use of Rock Fill.—In building hydraulic-fill dams, the debris above the solid rock has been most easily worked and extensively used. Such debris is frequently fine in grain size, and its use may result in an excess of core material and a deficiency of toe material. To correct this tendency, rock drill has been added to the toes of a number of dams.

The rock fill has usually been placed as dry fill; that is to say, by blasting, steam shovel, and cars or carts. The cars or carts run on the toes of the dam and deposit material at the same time that the hydraulic process is being used to fill the interior.

At the San Pablo Dam, a similar result has been reached by handling the rock after blasting by the hydraulic method. Open flumes were used with a flow of from 15 to 20 cu. ft. per second. A 6 per cent slope was necessary as long as wooden flume bottoms were used. With steel flumes, equally favorable results were obtained with a 4 per cent slope. About 3,000 cu. yd. per day were placed, on an average. Pieces of broken rock up to 1 cu. ft. in size were handled under these conditions. By blasting the hardest rock available, it was possible to get material for fill that contained relatively few fine particles, and all of the small quantity of very fine material was wasted. Large additions to the toes of the dam were made in this way.

Working a quarry with a high face, it was possible to throw down great quantities of material in one large blast, and to wash many thousands of yards into the dam from a single position of monitors and flumes. The economy resulting from operating so long in one place, as compared with moving the equipment all over the hillside to pick up scattered and relatively thin deposits of debris above the rock, turned out to be fully equal to the additional cost of rock excavation; and rock fills, built in this way, cost no more per cubic yard than fill made from debris.

On the other hand, the fill made in this way is believed to be heavier, and to have a higher coefficient of friction which gives it additional value as toe material.

Quicksand Condition in Dams.—The conditions that control the stability or lack of stability in quicksand may also control the stability or lack of stability of materials in dams.

The puddle clay core of an hydraulic-fill dam is physically like quicksand, but with particles 100 times smaller in diameter and 1,000,000 times smaller in weight. It has the instability of quicksand in full measure and it retains it for a long time, or perhaps indefinitely.

With the coarse-grained part of an hydraulic-fill dam, that is to say, with rock toes, there may be also, at times, a similar condition. Generally speaking, it would be expected that such coarse-grained materials would have sufficient drainage to let out surplus water and prevent the possibility of an excess sufficient to destroy its stability. With hard-grained materials from glacial drift of New England and the Northern States, it is hard to conceive of a lack of drainage in gravel that would permit the accumulation of an excess of water. With the softer materials of the Pacific Coast, however, the conditions may be different. In the first place, these soft rocks by partial crushing under pressure produce fine material which tends to fill the remaining spaces and to reduce the drainage capacity.

On the other hand, each increment of loading applied to soft-grained material produces a certain compression and settlement; and with it a reduction in voids. This may happen to a toe of soft rock on the up-stream side of a dam against which water is being stored during construction. There is first an open condition with ample voids and ample drainage. As the dam is built higher, pressure increases; there is compression and reduction in porosity. Each additional increment of loading and compression means that a certain quantity of water representing the difference between the old voids and the new voids must be expelled. As long as the material remains sufficiently pervious to carry off this excluded water, the process of compression is harmless. The surplus water is pushed back into the reservoir and stability is retained. There may come a time, however, when the compression goes forward so rapidly that the surplus water cannot be carried off fast enough. When that point is reached (if it is reached), there will tend to be an excess of water in the interstices and that excess will transmit some of the pressure that was before carried only by the bearings of solid particles, and the frictional resistance of the material will be less, and perhaps much less, than it was before.

The thought has occurred to the writer, in looking at the material that slid in the Calaveras Dam, that something of this kind may have happened on a large scale—800,000 cu. yd. of fill flowed for a brief space, and then became solid. It was, in fact, so solid that in examining it afterwards, by samples and by borings, it was difficult to see how the material could have flowed—as it certainly did flow.

It may be that after the first movement there was some readjustment of the material in the toe that resulted in producing temporarily this condition of quicksand, and that destroyed for a moment the stability of the material and facilitated the movement that took place.

This will not account for the initial movement; but the initial movement of some part of the material might result in accumulating pressure, first on one point, and then on another, successively, as the early points of concentration were liquified and in that way a condition comparable to quicksand in a large mass of material may have been produced.

Summary.—To summarize briefly the points that the writer has attempted to make and to apply them practically to dam construction:

1.—It is not well to build an hydraulic-fill dam of material of which any large percentage consists of clay or of particles less than 0.01 mm. in diameter; and in general all such smaller particles may well be wasted and excluded from the dam.

2.—By reducing the construction pool to a minimum, and by controlling it and the quantities of water used for sluicing, the core material may be held to a certain degree of coarseness by wasting all smaller particles. An effective size of 0.01 mm. may reasonably be sought.

3.—To study by borings the actual consolidation of the material, and to adjust the construction of the upper parts of the dam to the demonstrated condition of that which lies below.

4.—To make the toes large enough to resist with an ample factor of safety the whole pressure of the core material as a liquid until there is demonstration of the solidification of the core to a point where horizontal pressure is eliminated.

5.—To increase the weight and solidity of toes by the use of rock fill, placed hydraulically or otherwise.

6.—Stability is increased by compactness. It is worth while to watch voids closely, and to make every effort to hold them at a minimum. The extra weight is advantageous, but security against compression and rearrangement with resulting temporary quicksand conditions, can be best reached in this way.

A strict application of these principles may reduce the number of hydraulic-fill dams that are built by eliminating that method of construction from consideration where the available material contains too many very small particles. It may also increase considerably the volume and cost of those that are built. It would seem, however, that following them to a logical conclusion, with such testing as can reasonably be done, will result in eliminating present uncertainties and in putting a most useful method of dam construction on a definite and safe basis.

Required Capacity of Continuous Thickeners

Formulas for tank area and volume of sludge zone required are interesting features of a paper entitled "Settling Problems" presented April 8, by Willard A. Deane of The Dorr Co., before the Boston meeting of the American Electrochemical Society.

Continuous thickeners are a practical solution of the continuous settling and consequent continuous removal of sludge problem. The continuous thickener embodies two essential components, namely, the tank proper and the mechanism. The mechanism consists of a slowly revolving vertical shaft at the bottom of which are attached four radial arms with plows so arranged that their circuitous movement over the bottom of the tank draws the sludge evenly from all parts of their path to the center tank discharge.

In the process of "continuous settling" there is maintained in the tank an upper zone of clarification and a lower zone of thickening and just as long as the feed and discharge are at the same rate and other conditions remain constant, the relative height of these two zones will remain unchanged.

The following general rules governing the capacities of continuous thickeners hold true:

A. The clarification capacity is directly dependent upon the area of the thickener and independent of the height of the thickener, except in cases where there is an increasing rate of settlement.

B. The thickening capacity is directly dependent on the volume of the thickening zone and indirectly dependent upon the height inasmuch as this volume for a thickener of predetermined area can only be affected by change in height.

Clarification Capacity.—The more rapid the settling rate of the particles, the smaller the thickener area required, the relationship being expressed by the formula $A = \frac{4(F - D)}{3\ R \times Sp.}$ in which

A represents unit thickener area in square feet per ton solids per 24 hours.
R represents settling rate in feet per hour.
Sp represents specific gravity of liquid.
F represents ratio of liquid to solids in inlet
D represents ratio of liquid to solids in discharge.

The derivation of this formula is easily understood if we consider a tank being fed with a suspension of dilution F and discharging a thickened product of dilution D, the initial settling rate of the particles in the clarification zone being at R ft. per hour.

Since there were F tons of liquid per ton of solids entering and D tons of liquid per ton of solids being discharged, there must be F — D tons of liquid overflowing per ton of solids in the feed; or, stated in pounds, there would be 2,000 × (F — D).

Converting to volume in cubic feet we have

$$V = \frac{2000\ (F - D)}{62.5 \times Sp} = \text{cu. ft. of liquid overflowed per ton}$$

solids per 24 hours.

It is evident that when the solids settle through a distance of R ft. the R. ft. of clear liquid will be left behind and that in 24 hours at a rate of R ft. per hour, 24 R ft. of liquid could be removed. We have already shown that the volume of this liquid in 24 hours would amount to

$$\frac{2000\ (F - D)}{62.5 \times Sp.}$$

Therefore the area required would be $\frac{\text{volume}}{\text{height}}$ or

$$A = \frac{2000\ (F - D)}{62.5 \times Sp. \times 24 \times R} = \frac{2000\ (F - D)}{1500\ Sp. \times R.} = \frac{4\ (F - D)}{3\ Sp. \times R.}$$

Thickening Capacity.—The volume capacity of a tank in the thickening zone for a specified moisture content in discharge depends directly on the time or period of detention required for the sludge to reach this density and may be determined from the following formula:

$$V = \frac{4T\ (G - Sp)}{3G\ (S - Sp)}$$

where

V represents volume in cubic feet required for thickening per ton solids per 24 hours.
S represents average sp. gr. of sludge.
Sp represents average sp. gr. of solution.
G represents average sp. gr. of solids in sludge
T represents period of detention in hours.

Derivation of this formula is as follows:

The weight of solids in pounds in 1 cu. ft. of thickened sludge $= \frac{S \times 6.25}{D \times 1}$, where D represents the ratio of liquid to solids in sludge by weight.

Therefore, the cubic feet of sludge containing 1 ton of solids would be

$$\frac{2000\ (D + 1)}{S \times 62.5}$$

and on a basis of solids per 24 hours the volume for 1 hour would amount to

$$\frac{2000\ (D + 1)}{S \times 62.5 \times 24} \text{ or } \frac{4\ (D - 1)}{3S}$$

and for a period of detention of T hours—

$$V = \frac{4T\ (D + 1)}{3S}$$

It can be shown that the following relationship exists between dilution and specific gravity of the solution solids and sludge:

$$D = \frac{Sp\ (G - S)}{G\ \ (S - Sp)} \text{ and } D + 1 = \frac{S(C - Sp)}{G(S - Sp)}$$

substituting, we have

$$V = \frac{\dfrac{4T \times S(G - Sp)}{G(S - Sp)}}{3S} = \frac{4T\ \ (G - Sp)}{3G\ \ (S - Sp)}$$

These formulas may be applied to the design of sewage treatment works in which the continuous thickener method is employed.

Water Power Privilege: Relation of Head on Limiting Orifice to That Operating the Wheels for Maximum Power

By J. W. LEDOUX

Consulting Engineer, Philadelphia, Pa.

In many of the old grants for water power on various rivers the practice has been to define the amount of water permitted to be taken as that which will pass through an orifice of a given size and character. The owner of the privilege then knowing the total head available must determine the size of wheel that will utilize the maximum power. This is very easily arrived at, as follows: Let a be the area of the orifice, H the total head available, h the head lost through the orifice, h_1 the head acting on the wheels, Q the quantity of water per second passing through the wheels and P the power developed. The formula for flow through an orifice is $Q = ca \sqrt{h}$ (1) in which c is the product of the constant coefficient of discharge into $\sqrt{2g}$. Also $P = c_1 Q\ h$ (2) in which c is the efficiency of the wheel. Also $h = H - h_1$ (3), then

$Q = ca \sqrt{H - h_1}$ ....(4)

From (2) and (4) $P = c_1 ca \sqrt{(H - h_1)}\ h_1$ ....(5)

or $P = c_1 ca \sqrt{(H\ h_1^2 - h_1^3)}$ ....(6)

For maximum power.

$\frac{dP}{dh^1} = O = \frac{c_1 ca}{2} \cdot \frac{(2H\ h_1 - 3\ h_1^2)}{\sqrt{H\ h_1^2 - h_1^3}}$ ....(7)

Hence $2\ H\ h^1 - 3\ h_1^2 = O$ ....(8)

and $h_1 = 2/3\ H$ ....(9)

Since $h = H - h_1$ $h = 1/3\ H$ ....(10)

Hence $Q = ca \sqrt{H/3}$ ....(11)

c is generally 8.03 × .62, depending on the charaeter of orifice We may say

$$Q = 2.88\ a \sqrt{H}$$

Knowing a in square feet and H in feet we readily obtain Q in cu. ft. per second, which determines the size of the wheel or wheels for maximum power of the given privilege.

Expediting Pipe Line Calculations

The derivation of quick methods of calculation of pressure, power required, etc., in oil pipe lines, given by Mr. S. A. Sulentic in a recent paper before American Society of Mechanical Engineers, should be of interest outside the field of oil transportation because of the suggestion it carries for the introduction of similar short cuts in other fields. The variations of pressure as the square of quantity, and of length of line as the fifth power of the diameter are the means used by Mr. Sulentic in deriving his final results. The derivation follow:

Disregarding viscosity, the general hydraulic formula for friction head in a pipe discharging an uniform volume is

$$F = k\frac{v^2L}{2gD} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots [1]$$

in which

F = friction head in feet of water, lb. per sq. in. ÷ 0.433.
k = friction coefficient for 38 gravity oil = 0.024.
v = velocity of flow, ft. per sec.
g = acceleration of gravity = 32.2 ft. per sec.^{2}
L = length of line, ft.
D = diameter of line, ft.

The formula for pressure in the line may be stated as

$$P = 0.433\ k\frac{v^2L}{2gD} \quad \ldots\ldots\ldots\ldots\ldots\ldots [2]$$

in which P = pressure in line in pounds per square inch.

The discharge Q of the line, cubic feet per second, can be easily derived and stated as

$$Q = \pi\frac{D^2v}{4} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots [3]$$

in which Q varies directly as v. Since P varies directly as v^2 in Formula [2] and Q varies directly as v in Formula [3], it follows that P varies directly as Q^2.

The net horsepower required for a pipe line may be most readily calculated if we note that the pressure per square foot is equal to the number of foot-pounds required to displace 1 cu. ft. of oil, or

$$\text{Hp.} = \frac{144\ PQ}{550} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots [4]$$

For 1,000 bbl. per day against a pressure of 1,000 lb. per square inch, the net horsepower necessary by Formula [4] would be

$$\text{Hp.} = \frac{144 \times 1000}{550} \times \frac{1000 \times 5.61}{24 \times 60 \times 60} = 17$$

where 5.61 = cu. ft. ber barrel.

Assuming a pump efficiency of 85 per cent, the horsepower of the engine would be 20. Here we have a very simple rule for calculating the horsepower from barrels per day and pressure in pounds per square inch; namely,

Net hp. = 17 × thousands of bbl. per day × $P/1000$
B.hp. = 20 × thousands of bbl. per day × $P/1000$

Since the horsepower varies directly as PQ and P varies directly as Q^2, it follows that horsepower varies directly as Q^3.

Another relation of value in making rapid pipe-line calculations is the ratio between the diameter D and length L with the discharge Q and the pressure P remaining constant. From the friction formula [2], it will be seen that P varies directly at v^2L/D. Assuming P constant, L varies directly as D/v^2. For the same discharge, Formula [3], that is, with Q constant, v varies directly at $1/D^2$. Therefore v^2 would vary directly as $1/D^4$. Substituting this value for v^2 above, it is seen that L varies directly as $D/(1/D^4)$, or in other words, L varies directly as D^5. This means that for the same discharge and pressure, i. e., the same friction, the length of the line would vary directly as the fifth power of the diameter.

Taking 6 in. as unity the fifth powers of several different diameters are as follows:

D =	6	8	10	12
D^5 =	1.0	4.2	12.8	32

An example will show how easily these relations are utilized. Let a proposed pipe line be made up as follows:

2 — 6-in. lines, 8 miles long (Y-branch)
1 — 6-in. line, 6 miles long
1 — 8-in. line, 10 miles long
1 — 12-in. line, 12 miles long

With the particular oil to be transported the pressure per mile when pumping 10,000 bbl. a day through a 6-in. line will be assumed as 20 lb. per mile. What, now, will be the pressure for 17,000 bbl. per day through above line and what will be the net horsepower and brake horsepower required?

Since P varies as Q^2, the pressure for 17,000 bbl. will be $\frac{17,000}{10,000}^{2}$ or 2.89 times the pressure for 10,000 bbl. The pressure in the line would then be 2.89 × 20 or 57.8 lb. per mile.

Inasmuch as the velocity is halved when using two 6-in. lines for the 8-mile section, each line carrying an equal amount of oil, the equivalent length of 6-in. line for each branch would be only two miles, the length varying directly as the square of the velocity. The length of 6-in. line equivalent to the 8-in. pipe would be 10 miles divided by the ratio of the fifth powers of the diameters 6 in. and 8 in. or 10/4.2 = 2.38 miles. In a like manner the length of 6-in. line equivalent to the 12 miles of 12-in. pipe would be 12/32 or 0.37 miles. In other words, the equivalent length of 6-in. pipe in the line under consideration would total 12.75 miles. Under a pressure on the line of 57.8 lb. per mile, the total pressure on the line would be 12.75 × 57.8 or 737 lb.

Making use of the simple formula for horsepower already derived we have

$$\text{Net Horsepower} = 17 \times \frac{17,000}{1000} \times \frac{737}{1000} = 213$$

$$\text{Brake Horsepower} = 20 \times \frac{17,000}{1000} \times \frac{737}{1000} = 250$$

No doubt many other useful relations could be derived for the purpose of expediting pipe-line calculations, but those which have been presented are among the most useful.

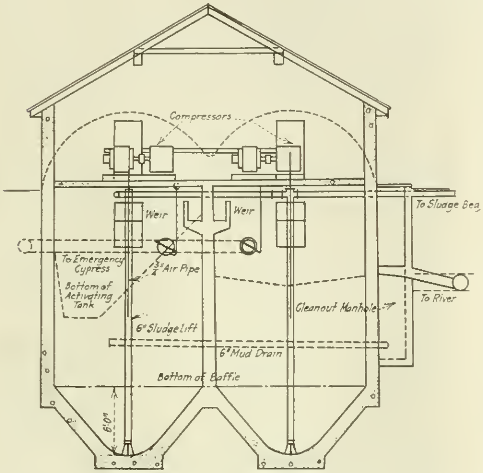
"Those Health People Get Big Results"

In his "How to Keep Well" column in a recent issue of the Chicago Tribune, Dr. W. A. Evans reports the following conversation that he overheard while on a railway journey:

> Three men boarded the train at 10 o'clock p. m. about 100 miles out of Omaha. Passengers for that city were compelled to sit up until 1 a. m. The conversation of the three men related to building dams, bridges, railroads, court houses and other large buildings. They were probably engineers and contractors. Presently one picked up the Bee and read aloud a dispatch telling that Gen. Gorgas (he pronounced it Gorgess) had been employed to make Peru healthy. He was hired by the Rockefeller Fundation under an arrangement with the government of Peru. The job was good for five years and the pay was $15,000 a year.
>
> "Can he do it?" asked the fat one. "Sure he can," replied the one with glasses. "Give him the money and the power." "But what's there to this talk about having the intelligent support of an intelligent rank and file?" "Nothing to it," said the man with glasses. "Didn't he clean up Cuba? Where was the intelligent co-operation of the rank and file? Didn't he make Panama healthy? He didn't get any intelligent co-operation from the West Indian Negroes who make up the labor population there. No, sir. What you need is the money and the power, that's all. See how he kept the death rate of the army down because he had the money and the power. Fifteen thousand dollars a year! That's no pay for that job," said the reader.
>
> "O, all those health fellows are cheap guys," put in the man with specs. "I notice that John D. pays the bill. Think of what John D. would have charged as his rakeoff for making Peru healthy."
>
> "But that is different," said the fat man. "John D. was the greatest middle man, the greatest merchant in the world. He changed the methods of marketing a commodity universally used. He was entitled to big brokerage."
>
> "Right you are," said he of the specs. "But didn't 'Gorgess' make the building of the Panama canal possible? What did anybody ever do that made more change than what 'Gorgess' did in Cuba and what grew out of it everywhere in Central and South America?"
>
> "Well, those health people do make people change. They do get big results. Why don't they ask more for what they do?"
>
> Here the conversation shifted slightly. Said one: "I wonder why somebody don't try that army health stuff on a civilian population? They had no flies in the army camps. I wish somebody would make Omaha flyless this summer," said the fat man. "They tell me there are no flies in Havana. Maybe there are none in that country." "Don't you think it," said the man with specs. "Go into any little place 40 miles from Havana where nothing to prevent flies is done and more flies will light on your bald head than you will find on a dead horse in South Omaha."

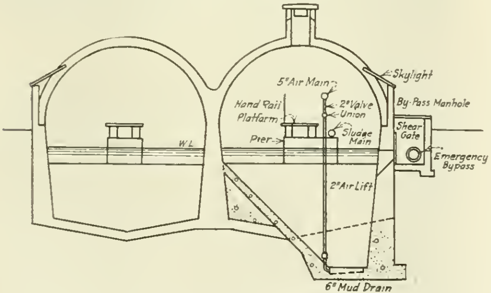
Reconstructed Septic Tanks Serve As Activated Sludge Plant

Since June, 1919, the town of Brampton, Ont., has successfully treated its sewage by the activated sludge process in remodeled septic tanks. The operation of the two original septic tanks created such a nuisance that lawsuits followed and eventually resulted in reconstruction of the tanks to serve as an activated sludge plant. A description of the remodeled tanks and the construction work appeared in an article by G. Graham, Contracting Engineer, Toronto, in a recent issue of The Contract Record, from which the following is abstracted.



Section of Settling Tank and Compressor House.

The original tanks were 100 ft. long with concrete arched air-tight roofs and practically flat floors. The remodeling consisted in deepening one of the old tanks to serve as an aeration chamber, and the addition of a compressor house over a settling tank at the outlet end.



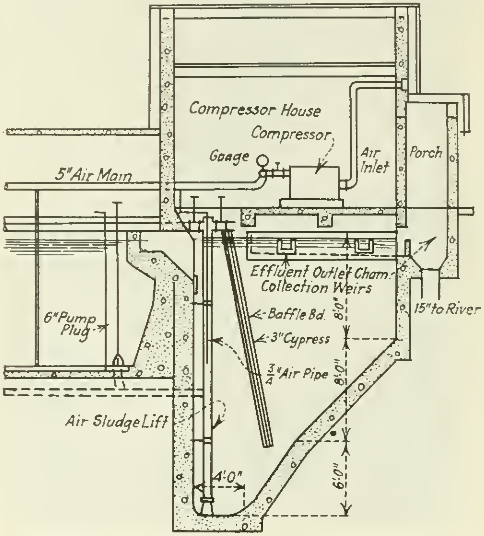
Section Showing Method of Reconstructing One of Pair of Septic Tanks to Make Activating Chamber.

A cross section of the septic tanks shows the manner in which one of them was deepened. One of the longitudinal walls was carried down about 6 ft. The opposite wall was brought down on a 1:1 slope which started about 6 ft. above the old floor and connected with a horizontal bottom 3 ft. wide. On this bottom width were installed the filtros plates. The original tank was divided into six sections by cross walls. The center wall was carried down with the new work and formed two separate basins and the remaining walls were arched over the deepened portion. The two compartments are so connected that either one may be by-passed when cleaning is necessary. A walk supported on wood beams ran along the center of the tank as shown on the cross section. This was renewed and the piers under it were extended to one side to hold the sludge return line and the 5-in. air line; 2-in. vertical air lines with globe valves supply the air to the filtros plates. The roof was left intact, but four old manholes were cut down and fitted with steel sash glazed with wire glass. Two ventilators were also built on the roof in order that the place might be as inoffensive as possible.

The settling tank at the end was built 16 ft. x 30 ft. inside and 22 ft. deep below the water line. It is designed with two chambers which slope to hoppers 4 ft. x 4 ft. in plan. The tank was floored over at the ground level and the compressor house built on top.

The sewage flows over weirs at the outlet end of the aerating tank down under a wooden baffle in the settling tank, thence upward over lateral wooden weirs into a main reinforced concrete weir built on the central wall of the settling tank. From here the flow passes out of the chamber into the sewer leading to the river.

The compressors are two in number and are of the motor-driven centrifugal type. An air-lift conveys a portion of the sludge from the bottom of the settling tank back to the inlet end of the aerating tank. The remaining sludge is also pumped by air-lift to the sludge drying beds outside. The compressor house is of reinforced concrete with wooden roof and asphalt shingles.



Section Through Settling Tank and Compressor House.

About 280 cu. yd. of concrete were used in the whole, but this was spread out so much that the work was very expensive. The work was carried out in winter during the war and considerable trouble was experienced in getting workmen.

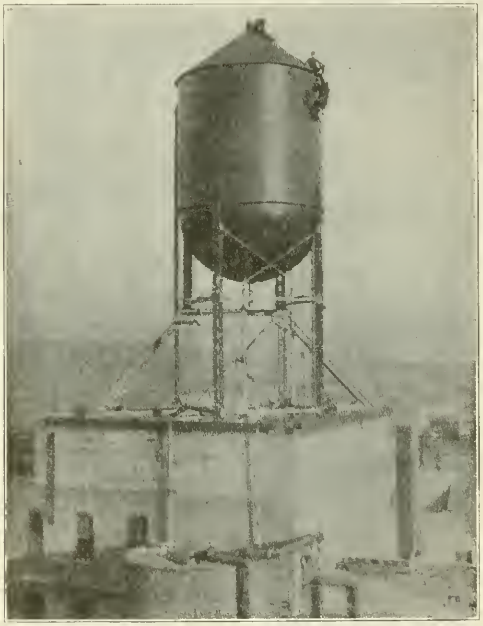
The plant has been in operation long enough to know what results it will give. It is being operated 15 hours a day and only one man is necessary to look after it. The former nuisance is abated and the plant has received the approval of the Provincial Board of Health.

St. Louis Convention of the A. A. E.—Among the speakers at the sixth annual convention of the American Association of Engineers held at the Planters Hotel in St. Louis on May 10 and 11 were M. O. Leighton, chairman of the national service committee of Engineering Council, who spoke on "Getting Salaries for Public Service Engineers Into Budgets"; Francis A. A. Kellor, vice-chairman of the Inter-Racial Council of New York and a recognized authority on immigration and racial problems, who spoke on "The Manpower Engineer—The Opportunity of Americanism," and Fred Lavis of the American International Corporation of New York discussed "Opportunities for the Engineer." The principal speakers at the banquet on May 11 were Doctor F. H. Newell, president of the American Association of Engineers and head of the department of civil engineering at the University of Illinois, and L. K. Sherman, president of the United States Housing Corporation.

50,000 Gallon Hot Water Tank and Tower

A 50,000-gal. tank and tower, unusual from a standpoint of design and utility, has been installed recently by the Chicago Bridge & Iron Works at the Wilmington, Del., plant of the Amalgamated Leather Co. The following account of the structure is taken from April issue of "The Water Tower."

The tank and tower is supported by an L-shaped wall at the corner of one of the highest of the buildings which comprise the plant, the supporting building being seven stories high and the L-shaped wall being located approximately in the center of a group of buildings. As the building is very old and contains numerous machines which cause considerable vibration, a thorough inspection of the walls under the tank was made by the Architects, Brown & Whiteside. These walls seem to be well made and capable of supporting the load, so that if the foundations are of the same grade as the walls, no trouble is expected. The "L wall" was built on the old building walls prior to the erection of the tank. It is 13 in. thick and extends a distance of about 7 ft. above the roof line.



50,000-Gal. Hot Water Tank of Amalgamated Leather Co.

The tank has a hemispherical bottom but no balcony, is built to the standard dimensions of the Chicago Bridge & Iron Works, is provided with the usual revolving ladder and with flanges for the numerous pipes mentioned below.

The four-post two-panel tower is of such height as to elevate the tank about 25 ft. above the roof line. Two adjacent columns rest directly on the wall and the other two rest on a truss which spans the distance between the ends of the "L wall." The top chord of this truss is about on line with the center struts of the three other sides of the structure and takes the place of the strut on the truss side. The lower ends of the long posts are tied to each other and to the truss by rods and bottom struts in the usual way, thus making the structure a very rigid unit.

To distribute the rather large load of the tank uniformly over the 13-in. wall, a set of two 15-in. beams were placed on each leg of the "L wall," each set of beams supporting one of the columns and one end of the truss. These beams are held in place by anchor bolts about every 4 ft. and are grouted in place to provide a thorough bearing on the wall.

The leather company in the production of leather uses as high as 30,000 gal. per hour of water having a temperature of 150°. It was on account of this large demand for hot water that the tank with heating apparatus was installed. The water is heated by exhaust steam from the engines in two groups of buildings and also by hot water from the economizer of the boilers.

A 10-in. wrought iron pipe header extends between 10-in. flanges placed at opposite sides at the top of the tank. To one end of this header is connected the 10-in. exhaust steam line from the larger engine and to the other end is connected the 6-in. exhaust steam line from the smaller engine. Twelve coils connect to 12 points on this header and extend downward to a 3-in. header located approximately at the balcony line. A 3-in. pipe connected to this lower header carries the condensed steam to the boiler feed pumps. The above mentioned coils are each composed of 25 turns of 3-in. extra heavy wrought iron pipe and are hung from channels at the top of the tank. There are 3,385 ft. of pipe in the 12 coils, making a total of about 45,000 lb. of pipe in the interior tank. The economizer is also used to boost the temperature of the water in the tank. The hot water from the economizer enters the tank through a 5-in. connection in the side at the top and the colder water returns through a 5-in. connection in the tank bottom. Hot water is supplied to the plant through an 8-in. pipe connected to the tank bottom. The finial at the peak of the roof is provided with holes to allow for ventilation. The entire surface of the tank is to be covered with magnesium covering to prevent radiation to the surrounding atmosphere.

Some question arose as to the stability of the "L wall" to withstand the thrust produced by the wind on the tank, inasmuch as the wall originally extended 7 ft. above the roof line without lateral bracing of any kind. With the wind blowing in almost any direction a rotation tendency of the structure and wall was apt to have been produced about the corner of the building. To prevent a possible collapse of the structure on account of this tendency, wing walls have been built, at our suggestion, extending from a lower adjacent building and butting against one leg of the L wall. To prevent rupture of the other leg, a channel was placed vertically bearing against the outside of the building. This is held in place by bolts to the wing wall and by long tie rods to the building.

Causes of Color in Reservoir Water

Some interesting comments on the causes of color in water are given by Mr. Caleb Mills Saville, Chief Engineer and Manager of the Hartford, Conn., Water Department, in his 1919 report, from which the following is quoted:

Some rather high colors are found in the various waters supplying Hartford. Of the present reservoirs, Nos. 1 and 4 are the highest and Nos. 2 and 6 the lowest. These are all old reservoirs and their condition is so stabilized that little or no changes from year to year may be expected under ordinary conditions. Such matters are attended to by cutting of weeds on the shores when the water is low, by planting coniferous trees along the reservoir shores to act as a screen to prevent leaves of other trees from getting into the water, and by some swamp drainage. The average color in the Nepaug Reservoir is considerably lower than for the past two years, as was anticipated. The reduction of color here has followed to a very remarkable extent the predictions made by Mr. F. P. Stearns, Consulting Engineer, two years ago, and the results are such as to warrant belief that the expectation of a future color of this water comparable with the best that Hartford now has will not be disappointing. While the natural influences are at work to bring about this result, this time can be hastened and possibly even better results obtained by swamp drainage in the area tributary to Phelps Brook, which the board plans to undertake. The swamp area here is comparatively small and mostly on land now owned by the board. From this area, however, comes most of the color produced outside the reservoir proper. Other causes producing color in the reservoir will be gradually eliminated by natural agencies. Those in the water shed, however, will be perpetuated unless the action above referred to is taken. The results obtained elsewhere make it certain that the improvements stated above are of great value and it is intended to undertake them from year to year with the forces of the board.

POWER AND PUMPING SECTION

This section of the Waterworks and Hydraulic Monthly issue of Engineering and Contracting is devoted to the selection of power and pumping equipment and the economic management of its operation.

Economy from Use of Variable Speed Induction Motors for Driving Centrifugal Pumps

The centrifugal pump is inherently a variable speed machine. The usual arrangement is to connect a constant speed motor directly to the pump. By substituting a variable speed induction motor, the efficiency of the centrifugal pump for varying conditions of head and quantity may be increased with a consequent saving in cost of operation. Some actual tests to verify these statements have been recently made at the University of Illinois and the general results are given by Prof. Melvin L. Enger and Prof. William J. Putnam, of the University, in a paper read before the recent annual meeting of the Illinois Section of the American Water Works Association at Urbana, Ill. An abstract of the paper follows.

There are four general conditions under which pumps operate: (1) constant discharge against a constant head, (2) constant discharge against a variable head, (3) variable discharge against a constant head, and, (4) variable discharge against a variable head. The first condition is the ideal one for centrifugal pumps driven by constant speed motors. Pumps delivering water to filter plants or to surface condensers often fall into the second class. The third condition is probably a rare one. In the fourth class would be included pumps used in waterworks plants for delivering water into distribution systems, because in this case variations of the water level in reservoirs and elevated tanks cause the head to vary, while variations in demand cause the quantity delivered by the pump to vary. In the last three cases it is customary to select motor-driven centrifugal pumps operating at constant speed which will operate satisfactorily under the most adverse conditions, and to control the head and discharge by valves at all other times.

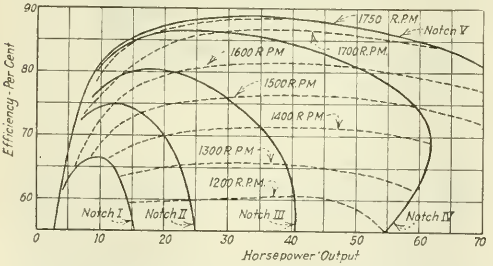


Figure 1—Relation of Horsepower Output, Efficiency and Speed of a Westinghouse 50 Hp., 440 Volt, 60 Cycle, 2-Phase, Variable Speed Induction Motor.

The variable speed induction motor has a wound rotor with its terminals connected to slip rings so that the resistances may be introduced into the rotor circuit to change the speed. The action is somewhat analogous to slipping a clutch to secure lower speeds, and is of course wasteful. In the Standard Handbook for Electrical Engineers it is stated concerning the variable speed induction motor:

> For any one value of the resistance the speed changes greatly with variations of load and rises practically to synchronous value at no-load, whatever the resistance. The higher the resistance, the more the speed will vary for a small change in load. An amount of power proportional to the speed reduction is lost in the resistance, that is, if the speed is decreased to 30 per cent below normal, 30 per cent of the energy taken from the line is lost.

Figure 1 shows the relations between horsepower output, efficiency and speed of a 50-HP. Westinghouse variable speed induction motor used for driving a DeLaval three-stage centrifugal pump in the hydraulic laboratory of the University of Illinois. The results of the test of this motor bear out the statements quoted above.

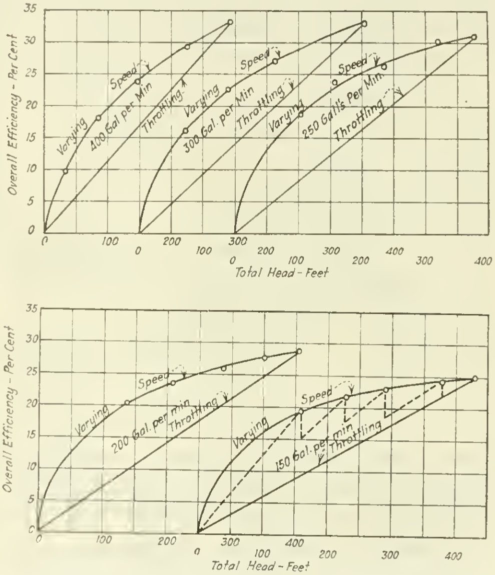


Fig. 2—Tests Showing Relative Over-all Efficiencies of Motor Driven 3-Stage Centrifugal Pump for Various Heads and Discharges When Pump Is Run at Normal Speed and Discharge Is Throttled.

When the head developed by the pump is in excess of the head required under the given condition of speed and discharge, the excess head is usually wasted through a partly closed valve. The power input to the pump remains unchanged because the pump continues to deliver the given quantity of water against the same head no matter how much the valve is throttled. The power used in producing the excess head is wasted. If, however, the speed of the pump is reduced to the proper amount it will not be necessary to waste head through a valve. The head developed by a centrifugal pump varies as the square of the speed when the discharge is zero, and approximately so for any discharge within the usual range of operation. If the speed is reduced to 90 per cent of the original speed the head will be reduced to about 81 per cent of the original head. If this change of speed is accomplished by means of a variable speed induction motor, the efficiency of the motor will be reduced to 90 per cent of the original efficiency. The efficiency of the pump usually does not change materially within such a range of operation. If the head is reduced to 81 per cent of the original head by throttling a valve, the over-all efficiency will be reduced to 81 per cent of the original overall efficiency. That is, the use of the variable speed motor to decrease the head to 81 per cent of the original value reduces the over-all efficiency by 10 per cent, as compared with a reduction of 19 per cent in case a valve is throttled.

In the case of a motor-driven pump having an over-all efficiency of 55 per cent, delivering 1,000 gal. per minute against a maximum head of 100 ft., but operating against a head of 90 ft. half of the time, a saving of about $150 a year would be effected by the use of a variable speed induction motor instead of a squirrel cage motor, it being assumed that power costs 2 ct. per kilowatt-hour. Approximately the same saving per year would be effected by the use of a variable speed motor with a pump of the above capacity and efficiency for any maximum head provided that the pump operates half of the time at a head of 10 ft. less than the maximum.

Figure 2 gives the results of tests on a DeLaval three-stage centrifugal pump direct-connected to a Westinghouse variable speed induction motor. The over-all efficiency of the unit when delivering various quantities of water against various heads is shown when the speed of the unit is varied, and also when the unit is run at normal speed and the heads are obtained by throttling the discharge valve.

It will be noted that the saving in power effected by the use of the variable speed motor is large when considerable reductions of head are required. The motor driving the pump was arranged for only five running speeds. The smooth curves drawn through the points indicate the over-all efficiency if the resistances introduced into the rotor circuit could be made any desired amount. For the unit used in the tests it is necessary to throttle the discharge valve to obtain heads between those given by the five running speeds. The over-all efficiency for different heads is therefore as indicated by the dotted lines in the tests with the discharge of 150 gal. per minute.

In the selection of a variable speed motor to drive a centrifugal pump great care should be taken that the several speed changes shall all be within the range required to produce the specified range of head, and the more speeds within this range the better. The electrical manufacturing companies might well turn their attention to developing an external resistance having a large number of steps.

The resistances consist of cast-iron grids compactly arranged, and are connected with the motor through a controller of the type used on street cars. Considerable heat is developed in the grids when the motor is operated at the lower speeds. The grids should therefore be located where the heat generated will not be objectionable. Unless the operator is instructed concerning the advantages of the use of variable speed he is liable to conclude from the heat developed in the grids that it is better to throttle the discharge by means of a valve, because the energy loss in this case is not so apparent although, in general, it is about twice as great.

The variable speed induction motor is more expensive than the ordinary squirrel cage motor, but when the head varies considerably the saving in power resulting from its use will much more than pay the interest and depreciation on the additional investment.

Yes! Pumped Coal!

An installation with which coal is pumped through a pipe line has been in successful operation at the power station of Hammersmith Borough, England, since 1915. It is very recently, however, that particulars of the development have been made public. The following account is taken from an article by George F. Zimmer in a recent issue of Engineering and Industrial Management, London.

The scheme was developed by Mr. G. G. Bell, engineer and manager of the power station, as a means for getting coal into the works. The consumption is about 100 tons per day. The coal is received at a wharf in river barges holding from 50 to 150 tons. These are unloaded by crane and grab bucket in the usual way, and successive bucket loads are discharged into a large overhead steel receiving hopper on the quay. This hopper is covered with a grating with a 5-in. mesh, so that all coal passing this mesh will go through the plant. Beneath this hopper is an automatic weighing machine which records the amount of coal received.

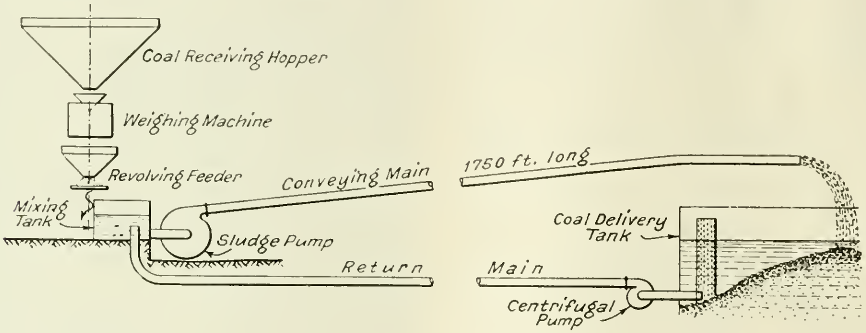
After the weight of the coal has thus been recorded it is dropped into a smaller hopper with a cone-shaped outlet which delivers in turn upon the revolving disc of a feeding device, which converts the intermittent coal supply from the grab and weighing machine into a continuous one.

A rectangular steel tank, about half-filled with water, is the next recipient of the now continuous stream of coal. This tank may be considered the receiving terminal of the pumping plant, in which the water and coal are automatically mixed and sucked into the inlet of a 7-in. centrifugal sludge pump driven by an electro-motor, the delivery pipe of which is connected with the 8-in. main pipe line which leads to and delivers into one of a series of receiving tanks at the power station 50 ft. in diameter each and 30 ft. deep. The pipe line has branches, and by ordinary sluice valves the stream of coal and water can be directed into any one of the delivery tanks.

There is a difference in level of 6 ft. 9 in. between this receiving and the delivery tanks, so that the coal travels on a rising gradient. The time occupied in the travel between the terminals is 7 minutes.

The proportion of coal to water is about half and half. When small coal or slack of the ordinary kind for feeding automatic stokers is handled; for larger coal the proportion of water is greater. The delivery-pipe terminates several feet above the delivery tank and the jet, which is of a dull black color, seems to have lost nothing of the liquidity of ordinary water. The pipe line which is fitted with a swivel joint is generally directed into the center of the delivery tank, from which a locomotive crane, and grab bucket, reclaim the coal, which is either allowed to drain in one of the five tanks or is delivered direct on to the band conveyor which feeds the boilers.

The water in the delivery tank has plenty of time to permit even fine particles of coal to settle to the bottom of the tank, and is then drawn off through perforated plates and led back through a return main pipe of the same nature to the receiving tank. A small electrically driven centrifugal pump is built into this return pipe at the power house, and this has been found necessary in spite of the



Diagrammatic Sketch of Coal Pumping Installation at Hammersmith.

gradient in favor of gravity. As the proportion of coal and water in the mixture changes with the size of the coal to be handled, it becomes necessary to admit additional water into the circuit when larger coal is being handled; this is allowed to enter into the receiving tank from the return main through a valve controlled by a float. If additional water is necessary, or if by some mischance the return water supply should fail. Arrangements have been made for a branch pipe from the condenser main—which is opened automatically—if the water level in the receiving tank sinks below a certain level. This is a wise and necessary precaution because a shortage of water in the conveying main would cause the coal to settle in the pipe with the consequent stoppage of the system.

When a barge has been emptied the water is permitted to circulate for 10 minutes after the coal supply has ceased in order to be sure that all the coal has been cleared out of the pipe. Another safety precaution is the provision of a storage dump upon which the grab bucket at the quay can discharge. This same expedient, however, is provided in the first instance to meet the case when five coal storage tanks are full. These tanks each hold 1,750 tons of coal which is stored under water.

These tanks were intended for a capacity of 1,500 tons, estimated on a basis of 40 cu. ft. per ton, but the coal lays so close together in this case.

The mains have an internal diameter of 8 in., and come in 30-ft. lengths. They are of the socket and spigot type, the joints being made of lead wool and tested to 300 lb. per square inch. The total length of the line is 1760 ft.; the power consumption is 50 HP., while the capacity is 50 tons per hour of coal. It might be mentioned that there is no perceptible difference in power consumption, whether the plant is running idle or conveying coal.

The consumption of electrical energy varies, and if coal in the barges has to be trimmed the power consumption goes on and the expenditure per ton is therefore higher. The highest record is 6 to 7 units, but when regularly at work the expenditure is only 3 units per ton of coal.

There are several bends in the pipe line, the largest being of a radius of 53 ft.; there are several of 3-ft. radius and one which has a radius of only 1 ft.

Previous to the installation of this system it cost. at prewar prices, 14 ct. per ton to get the coal from the wharf to the station. By the pumping system the coal is conveyed for 6 ct. per ton, this figure including power and labor.

Flood Flows in Nova Scotia

Heavy rains and a sudden warm spell over drainage areas covered with 2 to 3 ft. of snow, resulted in record-breaking floods over the western portion of Nova Scotia on March 13 and 14 last. In addition to the loss of many bridges and damaged roads, there were many failures of dams due primarily to inadequate spillway provisions, according to K. G Chisholm, Assistant Engineer, Dominion Water Power Branch, Halifax, in a recent issue of the Canadian Engineer.

The following table from this article shows the flood discharge for various streams. These were computed from surveys made immediately after the floods had receded and when the high water marks were readily discernible:

Stream.	Drainage area, sq. mi.	Flood discharge, sec. ft.	Flood discharge sec. ft. per sq. mi.
Nictaux	115	2,500	21.7
Annapolis, S. Branch	35	1,200	34.3
Annapolis at Lawrencetown	414	24,500	59.2
Lequille	48	2,500	52.1
Bear, E. Branch	79	4,000	50.6
Bear, W. Branch	30	1,800	60.0
Gaspereau	143	4,150	29.0

Following are some previous Nova Scotia records:

Stream.	Drainage aera, sq. mi.	Flood discharge, sec. ft.	Flood discharge sec. ft. per sq. mi.
Indian*	68	2,480	36.5
Margaree†	151	10,000	66.3
Philip‡	89	4,850	54.5
St. Mary‖	523	19,200	36.8

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*April 6, 1916. †May 14, 1918. ‡Oct. 22., 1917. ‖Jan. 5, 1918.

The three-day rainfall at Annapolis for the flood period was as follows: March 12, 0.35 in.; March 13, 3.26 in.; March 14, 1.21 in., or a total of 4.82 in. The rainfall at the other stations on the drainage areas was slightly less.

Remote Control Hydro-Electric Plants

The operation of remote control hydro-electric stations has, in one instance, been only a fraction of 1 per cent of the fixed charges. A description of this plant built two years ago and of one built only 6 months ago and also of a series of plants that are to be constructed is contained in an article by T. A. E. Belt, Lighting Engineering Department, General Electric Co., in a recent issue of The Electrical World. The following is an abstract of this article:

On Oct. 2, 1917, the automatic hydro-electric generating station of the Iowa Railway & Light Co. at Cedar Rapids, Ia., was put into operation. The generating equipment consists of three 400-kw., 0.8-power-factor, two-phase, 60-r.p.m., 2,300-volt vertical, water-wheel-driven synchronous generators, which tie into a system having 20,000-kva. in steam turbo-generators at the main station.

Water for driving the generators is obtained from the Cedar River by means of a concrete dam on top of which are automatic flashboards for raising the water level an additional 3 ft., making available a total head of 10 ft. The automatic station, which is connected to the steam station by two single-phase, concentric, 600,000-circ.mil cables, 3,000 ft. in length, feeds its entire output into the steam-station bus, from which distribution is made. A motor-operated wicket gate, supplied for each waterwheel, is controlled by a contact-making ammeter by means of which the generator load is regulated. The generators, which have individual float switches set to close their contacts at slightly different water levels, are started in the same sequence as that in which the individual float-switch contacts close. When the water level falls the generators are closed down in the reverse order from their starting; that is, generator No. 3 is closed down first and generator No. 1 closed down last. In the steam generating station are control switches, wired in parallel with the float-switch contacts through pilot wires, by means of which the starting of any automatically controlled unit is made independent of the height of the water in the forebay. The generators may be closed down by opening the control switches, and they cannot be restarted until the control switches are again closed.

Pilot wires carrying the secondary current of current transformers connected in the individual generator leads are run from the automatic generating station to the steam-operated station, so that the load on each generator is indicated at the steam plant. Two years of operation have proved that these pilot wires with their meters are not necessary and that they could have been omitted without decreasing the reliability of operation of the automatic station.

Excitation for the generators is obtained from either one of two induction-motor-driven exciter sets. Each exciter, which has sufficient capacity for supplying three generators, is rated 100 kw., at 125 volts, and is driven by a 2,300-volt, two-phase, 1,200-r.p.m. squirrel-cage induction motor.

At the time of the writing of this article the plant has turned out over 6,000,000 kw.-hr. with a total cost of inspection and maintenance amounting only to a small fraction of 1 per cent of the fixed charges. In other words, the cost of the power delivered by this plant is determined only by the fixed charges.

The correct sequence of operation in the starting of the plant is obtained by properly placed segments on the drum of a motor-driven controller which determines the proper time spacing between the different steps of the starting of the unit and connecting it to the bus.

The closing of the float-switch contacts or of the control switch in the steam plant starts the motor which drives the drum controller. The first segment of the controller to make contact causes a contactor to close, which throws full voltage on the induction motor of one of the exciter sets. In two or three seconds the induction motor, which is properly designed for this starting duty, comes to speed, taking only about six times normal current. The adjustment of the exciter rheostat is such that the exciter builds up to 125 volts.

Soon after the exciter is started another segment of the drum controller causes the motor-operated water-wheel gate to open sufficiently to drive the waterwheel and generator 70 r.p.m., corresponding to 70 cycles per second. After the gate is partly opened, the controller stops until the generator comes to a speed of 55 r.p.m., when the contacts of a centrifugal switch, mounted on the shaft of the generator, close, thus causing the controller motor to again start. When the controller starts for the second time the generator, without field excitation, is connected to the bus, in series with a reactance, which prevents an excessive flow of current. At the time the generator without field is connected to the bus its speed is approximately 60 r.p.m. The drum controller, which continues to revolve, causes the field of the generator to be excited at a low value, the excitation enabling the generator to pull into synchronism. By the closing of the proper circuits through the drum controller the field of the generator is strengthened to normal value. The reactance in the generator leads is then short-circuited and the controller motor is stopped, leaving the controller in the full running position.

As soon as the generator pulls into synchronism a contact-making ammeter connected to a current transformer in the generator leads takes control of the wicket gate, and is so adjusted that the wicket gate opens until the generator delivers full-load current.

The generator operates with a constant excitation, the value of which is adjusted for normal load. When the water level is low and normal kilowatt load of the generator cannot be carried with full gate opening, the generator, because of its overexcitation, takes care of part of the lagging current of the system.

The starting period of each generator is very short, requiring 39 seconds from the time the water-wheel gate begins to open until the generator is connected to the bus and the starting reactance short-circuited. Within 45 seconds from the first operation the generator carries full load. Although the starting period of each generator is very short, no mechanical jar is perceptible, and when the generator pulls into step with weak field excitation serious current surges are not experienced.

When the water is low the contacts of the float switch open, which cause the contactors in the generator leads to drop out and so disconnect the generator from the bus. The gate motor then closes the wicket gate and returns the controller to the off position, thus closing down the generator and the waterwheel. The unit may also be closed down by opening a control switch in the steam station. In case of overheating of the bearings, temperature relays close down the unit in trouble. Speeds and voltage of the generators are determined by the frequency and voltage of the steam station.

The remotely controlled hydro-electric generating station which was installed about six months ago by the Ontario Power Co. of Ontario, Calif., has been operating satisfactorily since its installation. During this time the maximum load carried by the generator has been about 75 per cent of normal value, owing to insufficient water supply. From the operation of the automatic control equipment at this reduced output, indications are that it will give complete satisfaction under full load conditions. The generator equipment consists of one 500-kva., 11,500-volt, 50-cycle, three-phase generator directly connected to Pelton waterwheel. Since the new plant, situated about 3.5 miles from the company's main generating station, utilizes the entire flow of the stream, provision is made to by-pass the water around the waterwheel when it is not running. By use of pilot wires to regulate the opening of the motor-operated needle valves the operator in the main station has complete control over the load.

In a proposed automatic system soon to be installed, several low-head water-power plants will be operated. Only one plant, containing one 240-kva., 120-r.p.m., 2,400-volt, three-phase, 60-cycle generator, with a transformer bank to step the potential up to 22,000 volts, is to be installed at the present time.

The automatic station will tie into the transmission system, which is fed by two 150-kva. steam-driven generators. The steam station will be operated at all times, but when the system load demands a greater generating capacity the hydro-electric plant will automatically start. As the water-storage capacity at the several plant sites is sufficient only to operate the generators at full load for about two hours, it is desired, when two or more plants are to be operated, to put the station where the pond level is the highest into operation first.

In order that the ponds may not be drained of water, the automatic stations will close down on light load; however, if the automatic station is carrying considerable load when the pond level is low, the float closes a limit switch, which shuts down the station. If one station is closed down by low water, another plant starts, provided the load reduces the frequency to 58 cycles.

The generator is protected by overload and bearing temperature relays, which when they operate close down the station. Since each relay is provided with hand-reset contacts, the restarting of the station is prevented until the contacts are reset by hand.

Water Power Development in Canada

According to a recent computation, the waterpower resources of Canada are in the neighborhood of 20,000,000 HP., or about 30 per cent. of the waterpower resources of the whole British Empire. Practically every great industrial center in Canada is now served with hydro-electrical energy and has within easy transmission distance ample reserves of waterpower. A number of statistics have been compiled by the Dominion Waterpower Branch, Department of the Interior, and the Dominion Bureau of Statistics, Department of Trade and Commerce, which have, through co-operation, just completed an exhaustive census and analysis of the developed waterpower in Canada. The figures have been brought up to Jan. 1, 1920, and are issued in a synopsis form from which the following data are taken:

According to the statistics there is installed throughout the Dominion some 2,418,000 turbine or water-wheel horsepower (Table I) of which 2,215,000 HP. is actually and regularly employed in useful work. The larger figure includes the total installed capacity at full gate, including reserve units. It does not, however, include hydraulic exciter units. The ultimate capacity of such plans, together with that of new plants now under construction, total some 3,385,000 HP.

Of the total power installed, 1,756,791 HP. or 72.7 per cent is installed in central electric stations. Central station power is sold for lighting, mining, electro-chemical and electro-metallurgical industry, milling and general manufacturing.

In the pulp and paper industry, 473,265 HP. is utilized of which 381,631 HP. is generated directly from water in pulp and paper establishments while 91,634 HP. is purchased from central hydro electric stations.

Hydro power used for other purposes and other industries may be listed as follows: For lighting purposes, 434,613 HP.; in mining industry, 177,728 HP.; in flour and grist mills, 42,736 HP.; in lumber and saw mills, 37,918 HP.; in other manufacturing industries, 172,955 HP. These figures are evidence of the widespread manner in which the Dominion's waterpower resources are being applied to the furtherance of its industrial development. In further reference to the foregoing total of waterpower developed in Canada, it might be noted that during the fiscal year ending March 31st, 1919, there were exported from plants included in the tabulation, 175,000 HP. years.

Table II analyzing the number and capacity of the water wheels and turbines installed, is of considerable interest. The total installation of 2,417,896 HP. is comprised of 3,370 units of an average capacity of 715 HP. While 2,244 of these units are of 100 HP. or under, they contribute only

TABLE I—DISTRIBUTION JAN. 1, 1920, OF DEVELOPED WATER POWER IN CANADA BY PROVINCES.

	Developed water power.				
	Total water wheel and turbine hp. installed.	Total hp. actually employed.	Ultimate designed capacity of plants now operating or under construction in hp.	Installed hp. per 1,000 population.	Undeveloped water power.
Yukon	13,199	11,349	13,199	1,467	100,000
British Columbia	308,167	276,795	350,832	429	3,000,000
Alberta	32,992	31,754	33,070	56	466,000
Saskatchewan	....	....	....	.....	567,000
Manitoba	83,447	75,100	297,047	135	3,218,000
Ontario	1,015,726	934,015	1,460,920	360	5,800,000
Quebec	910,029	838,071	1,146,465	391	6,000,000
New Brunswick	18,080	16,657	29,115	49	300,000
Nova Scotia	34,323	29,359	52,202	66	100,000
Prince Edward Island	1,933	1,621	1,958	21	3,000
Totals	2,417,896	2,214,721	3,384,808	274	19,554,000

TABLE II—TURBINES AND WATER WHEELS INSTALLED ON JAN. 1, 1920, IN WATER POWER PLANTS IN CANADA BY NUMBER AND CAPACITY OF UNITS AND BY PROVINCES.

	Total water wheels and turbines installed.	Units of 100 hp. or under.		Units over 100 hp. and under 500 hp.		Units of 500 hp. and under 2,000 hp.		Units of 2,000 hp. and under 5,000 hp.		Units of 5,000 hp. and under 10,000 hp.		Units of 10,000 hp. and under 20,000 hp.		Units of 20,000 hp. and over.	
	Hp.	No.	Hp.	No.	Hp.	No.	Hp.	No.	Hp.	No.	Hp.	No.	Hp.	No.	Hp.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Yukon	13,199	6	199	.	....	3	3,000	..	....	2	10,000	..	....	..	....
British Columbia	308,167	124	4,396	43	10,498	39	44,573	19	62,100	6	42,000	12	144,600	..	....
Alberta	32,992	9	492	5	900	..	....	2	8,000	4	23,600	..	....	..	....
Saskatchewan	....	.....	......		......	..	....	..	....	.	....	..	....	..	....
Manitoba	83,447	.....	......	1	450	2	1,000	9	35,597	8	46,400	..	....	.	....
Ontario	1,015,726	734	32,190	182	39,844	147	155,062	77	186,380	14	88,050	36	474,200	2	40,000
Quebec	910,029	893	31,942	189	46,626	140	151,461	51	157,825	22	151,075	20	251,100	6	120,000
New Brunswick	18,080	61	2,084	16	3,696	10	10,300	1	2,000	..	....	..	....	..	....
Nova Scotia	34,323	324	8,968	38	9,605	19	13,250	1	2,500	..	....	..	....	..	....
Prince Edward Island	1,933	93	1,933	..	....	..	....	..	....	..	....	..	....	..	....
Totals	2,417,896	2,244	82,204	474	111,619	360	378,646	160	454,402	56	361,125	68	869,900	8	160,000

82,204 HP. or 3.4 per cent to the total. A total of 1,845,427, or 76.3 per cent of the whole is contributed by units of 2,000 HP. and over; 1,321,025 HP. or 57.6 per cent by units of 5,000 HP. and over; 1,029,900 HP. or 42.6 per cent by units of 10,000 HP. and over; and 160,000 HP. or 6.6 per cent by units of 20,000 HP. and over. This table is illustrative of the modern tendency towards the installation of large units. Reference might be made in this connection to the 50,000 HP. turbines which are contemplated for the new development of the Hydro-Electric Power Commission at Queenston.

Ninety-one four-tenths per cent of the primary power used in the central stations throughout the Dominion is derived from water, evidencing in a striking manner the advantageous location of the water power resources to industrial centers. The total installed water wheel and turbine horsepower in hydro central electric stations is 1,756,791 HP. Fuel auxiliaries installed as stand-bys to these hydro stations brings the total installed primary capacity up to 1,873,989 HP. connected to 1,449,180 k.v.a dynamo capacity. The total capital invested in these central stations, inclusive of transmission and distribution systems, is $369,464,961 or an average of $210 per installed primary horsepower.

Of special interest to engineers is the actual cost of construction of hydro-electric power stations, exclusive of transmission and distribution systems. The figures of 70 representative hydro-electric stations throughout the Dominion with an aggregate turbine installation of 745,797 HP. show a total construction cost of $50,740,468 (pre-war figures) or an average of $69.11 per installed horsepower. This cost includes the capital invested in construction of dams, flumes, penstocks, and all hydraulic works, and of power stations and equipment. It excludes real estate and transmission and distribution equipment. The figure, in brief, represents the capital cost of construction at the power site.

With a waterpower development of 274 HP. per 1,000 population, Canada stands well in the forefront in respect to availability and utilization of hydro power resources, being only surpassed in this respect by Norway. The enormous waterpower reserves still untouched are an assurance of continued industrial expansion and prosperity for the Dominion.

Cost of Municipal Water Systems in Pennsylvania.—Data on the cost of municipally owned water works have been collected by the Water Supply Commission of Pennsylvania in connection with the preparation of a water resources inventory of the state. The following figures are taken from a recently issued report of the commission. The annual operating expense given was exclusive of fixed charges and an assumed figure, 6 per cent of the total cost, was added for interest, depreciation, etc., to obtain a total cost of furnishing the water. This cost varies for the larger boroughs and cities from $50 to $80 per 1,000,000 gal. In small places, with simple gravity systems, under most favorable conditions the cost is as low as $16; while for complex systems, figures between $200 and $400 are not infrequent, and in a few instances run higher. If the fixed charges were based on actual outstanding bonds the figures would, in many cases, be considerably less. The cost of the works per 1,000,000 gal. daily supplied varies from $100,000 or less to $350,000 for the larger boroughs and cities; and for smaller systems, using only small fractions of a 1,000,000 gal. daily, the rate ranges from $100,000 or less to $1,000,000, according to size and methods used.

Prevalence of Waterworks in Pennsylvania

Of the 614 water supply systems in Pennsylvania on Jan. 1, 1918, 450 were corporate, 163 municipal and one jointly owned. There also was record of 104 systems owned by mutual companies, partnerships or individuals, and 143 industrial water plants incidentally supplying employes' houses, making 861 systems of record of all classes. These figures are taken from a recently issued water resources inventory report of the Pennsylvania State Water Supply Commission.

The population supplied by individual systems varied from over 1,600,000 in Philadelphia to less than 100 in some rural villages, while the aggregate population supplied by waterworks was approximately 6,000,000, or 70 per cent of that in the state, including all the 35 cities, 641 of 926 boroughs, and many unincorporated settlements. Every place of over 2,500 population, and most of those between 1,500 and 2,500, have waterworks. Most towns of over 1,000 population were provided with public water supplies, but in some instances contiguous communities, whose combined population seems large enough to warrant it, have not been so provided. Many smaller boroughs and villages have waterworks, due to progressiveness and expected growth, or to an unusually favorable location of a source of water. The smallest borough with a public water system has about 200 population, and is served by municipal works, while the smallest unincorporated village system recorded is owned by an incorporated water company having only 15 consumers.

Table No. 1 from the above mentioned report indicates the prevalence of waterworks in Pennsylvania municipalities according to various ranges of population.

TABLE I.

Population 1915.	Number of municipalities of given population having a public supply.	Number under municipal ownership.	Number under corporate ownership.	Number not being supplied.	Approximate population of municipalities served with water.	Approximate total population of all municipalities.
Under 1,000	172	38	114	266	110,100	212,800
1,000 to 2,500	220	57	160	19	381,700	411,500
2,500 to 10,000	209	41	167	1	1,067,000	1,071,000
10,000 to 50,000	63	19	44	0	1,154,400	1,154,400
Above 50,000	12	8	4	0	3,020,300	3,020,300
Total	a676	b†163	c†149	d286	e5,733,500	5,870,000

aIncludes 24 supplied by plants owned by mutual companies, partnerships or individuals.
bIncludes one first class township.
cIncludes one town.
dIncludes one second class borough.
ePopulation actually supplied, 5,480,000.
†Where municipalities are served by two systems, tabulation has been made under the predominating system.

Approximately 500,000 people in more than 700 small settlements, not included in Table I, are served by water supply systems, more than half being in suburban districts, adjacent to greater boroughs or cities and supplied by the same system. The remaining population is scattered among isolated communities with local systems, of which about half are owned by incorporated companies, the rest being private industrial or domestic systems in the approximate proportions of three-fourths and one-fourth respectively.

The Engineer in Public Service*

By WILLIAM S. TWINING.

The variety of engineers is almost legion, and the latest variety that I have seen suggested is called a "political engineer." Apparently, this variety does not yet exist, but the suggestion is made that this variety is needed and should be created for the purpose of applying the principles of engineering to political affairs. Said a recent writer:

> It is our belief that the engineers of this country can and will be the prime movers in effecting a radical change in governmental management. They are the only large body of men trained to apply science in the solution of economic problems. The problems of political government are, in most respects, identical with the problems that engineers are accustomed to solve. Even where they differ in detail, the principles to be applied are the same.

Of the various varieties of engineers, we have supervising engineers and engineers who are supervised; professional engineers and trade engineers; engineers who originate ideas and initiate plans and engineers who execute plans. All classes, however, have one common characteristic in that they are all trying to serve their fellow-men and make this world a better place in which to live. They all have the constructive instinct which is the instinct from which civilization has developed. They live and plan for the future. As I use the word today, in connection with public service, I have in mind the professional or supervising engineer; the man who originates ideas or directs their execution; who is an administrator and whose qualities were recently set forth by Dean Ketchum as follows:

> A good engineer must be of inflexible integrity, sober, truthful, accurate, resolute, discreet, of cool and sound judgment; must have command of his temper; must have courage to resist and repel attempts at intimidation, a firmness that is proof against solicitation; flattery or improper bias of any kind; must take an interest in his work; must be energetic, quick to decide, prompt to act; must be fair and impartial as a judge on the bench; must have experience in his work and in dealing with men, which implies some maturity of years; must have business habits and knowledge of accounts. Men who combine these qualities are not to be picked up every day. Still, they can be found. But they are greatly in demand, and when found, they are worth their price; rather they are beyond price, and their value cannot be estimated by dollars. Stated somewhat differently, an engineer must have general training; must have technical training; must have professional experience; must have high moral character; must have a knowledge of men; must have a broad vision; must have administrative and business experience.

That is a pretty stiff specification and but few so-called engineers can fill it. I shall have to enter a disclaimer for myself here and now.

Engineer Pre-eminently Fitted for Public Service.—The engineer by instinct and training is pre-eminently fitted for the field of public service; for government today has passed far beyond the stage of simply exercising the police powers to the end and for the purpose of maintaining the unrestrained pursuit of happiness.

The idea of underlying government today is that of service to the public or community, and the evident dissatisfaction with government which exists all over the world today grows out of the fact that the machinery of government is lagging behind the requirements of the different nations in this matter of supplying adequate and satisfactory service to the communities governed.

The Engineer's Contributions to Public Welfare.—Engineers are primarily constructive, and under reasonable conditions a competent engineer will usually produce satisfactory results. From time immemorial, engineers have been the pioneers on the front line, blazing the way for an advancing civilization. As a matter of fact, all of our modern civilization is the outgrowth of engineering conception and development.

About 30 years ago, E. H. McHenry, then Chief Engineer of the Northern Pacific R. R., published a little booklet on railroad location, in which he laid down the dictum, "Engineering is the art of making a dollar earn the maximum of interest." During the past year the following definition has been suggested, "Engineering is the systematic application of science to the problems of economic service." There is a world of difference between these two definitions. The first conception is based on the engineer being the servant of the capitalist. It is the conception of a railroad man working for the stockholders' interest. The second definition is based on the modern conception that all industry exists for the purpose of supporting and contributing to the resources of human life, and not primarily as a source of private, corporate or state profit. It recognizes the modern idea that the primary object of industry is to render service to humanity, and to that end Doctor Eliot has recently borne testimony that engineers contribute more to the welfare and comfort of humanity than any other class.

Vast Difference Between Public Service and Business Fields.—A business man is animated and guided chiefly by the commercial instinct; that is, he tends to follow commercial pursuits; to follow trade, as distinct from the engineer whose instincts are seldom of the commercial variety. The commercial pursuits are foundamentally selfish and tend to individuality. The true engineering instinct is that of a servant. The engineer has been so long working for and serving others, and his commercial instincts are so little developed, that he has never established himself before the public like the doctors and lawyers as a distinct profession, although his services are acknowledged to be as indispensable to the service of the public as are those of the other professions. He cannot be classed with the commercial men because he has nothing to sell but his services. However comforting it may be to know that engineers are indispensable, it is neither complimentary nor satisfactory to imply that they can only function properly when their work is supervised by a man having commercial instincts. Engineers have proved themselves indispensable to the commercial classes, and a large number of them are employed in commercial pursuits. Although the engineer is not commercial by instinct, he is an apostle of efficiency, and the commercial man has recognized that efficiency is a source of profit.

The administration of government is not a commercial proposition; it is a question of public service, and there is to my mind no reason for assuming that because a man possesses commercial instincts and has spent the greater portion of his life in acquiring this world's goods he therefore is an able administrator of public service, which is not a money-accumulating but rather a money-spending process to the end that the people may be served properly. In the matter of real efficiency in money-spending, I believe the engineer stands pre-eminent. The mere fact that the so called business man when called upon to act as an administrator of government prefers that engineers shall head his various bureaus seems to be an acknowledgment of their fitness.

Why the Engineer Is Not More Prominent in Government Service.—The administration of a department of the government as now constituted consists in part of routine work and in part of the more important development work which grows out of the idea of service. It is this latter function for which real engineers are specially fitted. A real engineer chafes under the restrictions of routine work, and while we find many so-called engineers in the lower grades of government work, they are not strictly members of the profession of engineering, but of the trade of engineering; a draftsman, rodman or transit man is not strictly a professional engineer. The professional engineer is an originator of ideas as well as an executor of those of others. He is a man of thought as well as action, and his whole energy is applied to the rendering of service to humanity. Why, then, is he not more prominent in the greatest field of service, that of efficient government?

For the first reason, engineers feel that government service is so bound up with red tape that it is routine in its character and lacks initiative. This condition is abhorrent to a man who has been trained in efficiency methods.

Second, the public lacks respect for government employes, regards them as objects of suspicion, as a class, as to their honesty, and engineers of standing and character are fundamentally honest, and do not care to be associated with any class of work which might be a cause for reproach and require an apology for being associated with men of questionable character.

Third, the compensation for services rendered is usually lower than the comparative grade of private service is worth, and the engineer feels that advancement is uncertain and a matter of political preference or "pull" rather than merit; and in truth there is much basis for this feeling.

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*From an address Feb. 3, 1920, before the Engineers' Club of Philadelphia.

Lastly, the professional engineer is not a practical politician and is rarely associated with that class.

Lack of Permanent Employment.—Satisfactory government must, in the end, rest upon the administrative personnel.

The engineer should be the best qualified man to deal with the economic problems that abound in civil government. But whoever knew of a promising energetic young engineer at the outset of his career aiming to become an engineer of distinction in the municipal service? What inducement is there for a competent man to qualify for that line of work? There is neither permanence of position nor pay sufficient to command first-class men. The man required for the competent direction of a department of a large modern city must be a man who commands more money than the city will pay him. Such a man taking charge of a department severs his formerly established business relations in order to serve the city to the best of his ability for four years, and then in all probability he is disposed of to look about and pick up the lines of his profession as best he can.

The Modern Conception of Service.—The problems of government and industry are substantially the same, as they are both considered to be forms of service for promoting human welfare. There is this important distinction, however, which accounts for the development of government lagging behind the development of industry: Industry serves for profit, while government is expected to be rendered without profit; government is "service at cost," and in many cases far below the cost of proper service; industry provides substantial rewards for service, while government begrudges even adequate salaries.

In closing, I will leave with you a statement of the modern conception of service as applied to industry, and in my judgment, the same principle must be applied to government before we will have satisfactory government:

> Business that serves for profit instead of exacting profit must be the new order of things if the public, of which all of us are a part, is to be benefited; and this must be an obligation not of a single group, but of all groups.

You will note that in both the old and the new conceptions of industry, profit is the ultimate result of business. Under the old conception, profit was the object of business; under the new conception, it is the reward of business. In both the old and the new conceptions, the relationship of profit to industry must not be overlooked. The fundamental object of both government and industry is service, and service must always receive a reward; and that reward should be proportional to the value and quality of the service. Until these principles are recognized and machinery is devised for carrying out the principles, the operation of government will be unsatisfactory. The necessity of a reward for industry is everywhere recognized; and as service in the administration of government should be considered the highest form of service, a reward must be provided. Government administration will never attract the proper leaders until a suitable reward is provided. The reward need not be in the shape of money; in England it is given in the form of titles and in public honor and respect. It must be a reward which will induce the best element in the community to serve in public office. Lowell pointed out many years ago that if our form of government is to succeed, it must develop and set to work the highest types of human intelligence and character. That development can only be brought about by providing a reward which shall be proportional to the service rendered; and it behooves engineers, who must be included in the highest types of our citizenship, to take an active interest in this matter.

A Co-Operative Course in Municipal Engineering.—Arrangements have been made with the Director of Public Service of the city of Akron, O., whereby students in civil engineering at the Municipal University of Akron may pursue regular studies leading to a degree in the university while working half time in different engineering departments of the city. Such students will start as laborers and be employed in the street cleaning, paving, water and sewage departments. After a year of this work those developing the necessary qualifications will be advanced to minor positions of responsibility and have charge of small gangs at work in the departments mentioned. The last three years of the course will be spent in engineering positions beginning as rodmen and being promoted to inspectors, instrument men, office engineers, etc.

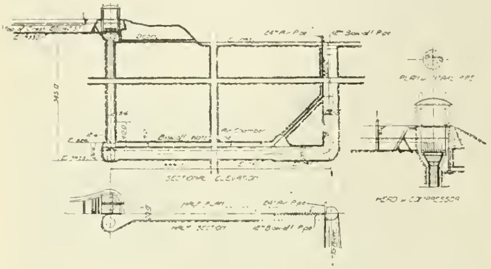
"Coming, the Engineer"

The daily newspapers are beginning to take notice of the engineer. Perhaps this is because engineers are beginning to take notice of the newspapers. Perhaps it is due to the work of the engineers during the war or to the fact that one of the prominent presidential candidates is an engineer. In any case, the profession is receiving much valuable publicity through the daily press. From many editorials that have come to hand recently we reprint the following from the Boston Globe of May 3:

> In the satchels of American engineers who are soon to board ship for Europe will be specifications which might appropriately be labeled, "Plans for the transfer of a little bit of Texas and Oklahoma to a corner of sunny France." As was so often predicted during the war, our friends, the French, having sampled our technical skill, are calling for it.
>
> This particular party of Americans will construct the first oil pipe line in Continental Europe, outside of the Rumanian fields. The United States Navy built a similar line across Scotland during the war, thus saving a hazardous trip through submarine-infested waters for Allied tankers. The French are up against it for coal. They are largely dependent for fuel upon oil, imported through Havre. Hitherto it has been carried by rail or water to Paris, but the railroads and the Seine are clogged with traffic. The burden will be eased by the ingenious device which American enterprise instituted in tapping the mineral reservoirs of the west.
>
> Perhaps there was no more useful consequence of the war than the exhibition of American construction feats right before the eyes of the French people.
>
> Early units of the A. E. F. arriving in Southern France, the agricultural section, where methods have been least subject to change, were real miracle-workers. The experts of a Southern French city inspected a river site where the Yankees were preparing to build concrete docks, and set 10 months as the minimum time required. The Frenchmen returned four months later and found whirring electric cranes hoisting from the holds of a dozen ships war supplies which were being loaded into American railroad cars and started on their way to the front.
>
> To be sure, after the war the docks had sagged, and the French, who place a premium upon durability, were reluctant to take them over. Ordinarily Europeans are more extravagant with time than with anything else. The Americans proceeded on the assumption that in war, whatever is wasted, it must not be time.
>
> France appreciated that lesson. A country which has had 20 centuries to develop its resources sat up and took notice when it saw exemplified the methods required to exploit a whole virgin continent in four. Speed has become essential to the French as they face the task of industrial reconstruction. Their job is the very one which has made the American engineer famous in every quarter of the globe.
>
> In certain specialized fields of endeavor French technical men have led the world. They have concentrated on such problems. In the manufacture of various products requiring a high degree of skill the French trademark has been the stamp of excellence. For obvious reasons they have led in producing effective artillery, and the French 75 was the Allied gun. They were quick to see the value of the airplane, and they have gone a long way with the gasoline engine. In industrial engineering they have been, as in agriculture, intensive. The American engineer is the fellow who has put over big things in a big way.
>
> It might be said that our engineers are to the French what Foch was to the American generals. Foch was the strategist who surveyed the whole war map and laid the big plans; the American generals were tacticians, specializing on local problems.
>
> We like to point with pride to the Panama Canal, a stupendous engineering stunt which was half a medical job. We accomplished this because our experts solved the medical problem that stumped the French.
>
> The development of untapped sections of the earth calls for the kind of imagination which in so short a time has uncovered the potential wealth of America and made the United States the richest country on earth.
>
> The motor truck road through the wilderness, a catch basin between two mountains converted into a reservoir, the irrigation system through the desert, are the kind of jobs which the American engineer has been trained to do and to relish. South America, Asia or Africa—any old shack where he can hang his hat—is home to him. And Europe, rising from the ruins, sees that his drive and resourcefulness can be used even in the places where our civilization had its birth and where the Roman originally paved the way for progress with roads and aqueducts.
>
> Mr. H. G. Wells thinks that the future belongs, not to the wizards of finance, but to mechanical experts, the fellows who make the wheels of the world go round and keep them going faster all the time. The type of mind which can reduce its visions in definite form upon blueprints is on a rising market. Even though one of their profession may not immediately step into the White House, the engineers have already achieved a sure claim on the future.

Hydraulic Air Compressor Plant

A power plant which converts hydraulic power into compressed air was described by H. S. Slocum, Engineer, Vielé, Blackwell & Bush, New York, in one of the 1918-19 J. E. Alfred Lectures on Engineering Practice at John's Hopkins University. The power in this form is transmitted for several miles where it is utilized for running drills, hoists, and other machinery in the Cobalt Silver mines. The reason the method is feasible and commercially successful in this case is because the hydraulic power is converted into the



General Arrangement of Hydraulic Compressor Air Plant at Cobalt, Ont.

attendant. The heads telescope into the intake shaft and are set just below the surface of the water, the position being regulated by means of air hoists to conform to the changes of river levels. Before the air in the chamber acquires a volume sufficient to cause it to discharge through the uptake shaft, it is released by a 12-in. blowoff pipe form of energy which can be used without other conversion, thus saving many losses.

The head utilized is 47 ft. A dam was built at the head of the falls and forebay, racks and gates are installed similar to those of hydro-electric plants. After the water passes through the racks it flows through two 16-ft. diameter heads in each of which are 66 14-in. diameter pipes. The water enters these pipes in swirls, drawing in with it a great deal of air which passes down the shaft with the falling water in the form of globules. As the water flows through the tunnel the air rises to the surface and collects in the air chamber under a pressure due to a head of 325 ft. or 125 lb. per square inch, from whence it is piped to the mines through a 24-in. pipe. The water then passes through the tunnel and up the outlet to the river.

The plant is practically automatic and requires but one

General View of Hydraulic Air Compressor Plant.

which has its lower end ordinarily submerged. The air compressed by this method is free from moisture and may be transmitted in the coldest weather without condensation and freezing. It is also free from oil, which eliminates the possibility of explosion in receivers.

Engineer Candidate for Congress.—One of the newest engineers to enter actively into the field of politics is Charles R. Anthony, county surveyor of Claire County, Pennsylvania, and a member of the American Association of Engineers, who is candidate for Congress.

The Work of the Water and Sewerage Laboratories of the Massachusetts State Board of Health

The first state board of health in this country was founded in Massachusetts in 1869. The latest issue of The Commonhealth, the official publication of the State Department of Public Health, is devoted to a brief summary of the 50 years work of the Board. Of particular interest is the account by H. W. Clark, of the work of the Division of Water and Sewerage Laboratories. This is reprinted below.

At the beginning of the work, in 1885, of the Department of Water Supply and Sewerage of the State Board of Health, laboratories for the examination of water and sewage were established at the Massachusetts Institute of Technology, and in 1887 an experiment station for investigations in regard to the purification of sewage, trades waste, the treatment and filtration of water, and allied subjects, was established at Lawrence.

In the laboratories at the Institute of Technology samples of water from the water supplies of the state, the rivers, etc., and of the sewage entering these rivers, and effluents of sewage filters were examined both chemically and microscopically, and the Lawrence Station was equipped with tanks, filters, etc., and chemical and bacteriological laboratories for the proper study of the subjects to be investigated.

In 1896 the Institute laboratories for the examination of water and sewage were removed to the State House in Boston and have been continued there.

The experiment station has been enlarged and improved from time to time, and although always modest in equipment, the investigations and studies carried on there have added greatly to the knowledge of the world in regard to the proper treatment and purification of water, sewage, etc. The work has been continued 32 years up to the present time, and from the first has been of such character that it is known in all countries interested in sanitary science.

Beginning with studies on intermittent sand filtration of sewage and water, together with laboratory investigations upon nitrification, the cause of the reduction of bacteria by filtration, etc., the work of the station has grown constantly, and has included experimental investigations, tending always towards the development of scientific and practical methods of sewage purification, the purification of manufacturing wastes of many kinds, the filtration or other treatment of water, and other special investigations in sanitary science, which have been described in many papers written by the experiment station staff.

The first report of the work of the station, published in 1890, was for many years the best known work on sewage disposal. In this report the results of studies of intermittent filtration of sewage in those early years was fully described, and many of the laws of filtration made clear. It was clearly shown by experiments that filters of gravel stone gave the best illustration of the essential character of intermittent filtration of sewage. Filters were constructed of stones so large that even the coarser suspended particles of the sewage were not removed, yet "the slow movement of the sewage in thin films over the surface of the stone with air in contact caused a removal for some months of 97 per cent of the organic nitrogenous matter, as well as 99 per cent of the bacteria." Special investigations upon the filtration of water, made during those early years, were also of great interest, and showed at what rates polluted water could be purified by slow sand filtration using the sands common in New England, and also showed the laws governing such filtration. The first result of this work upon filtration of water was the construction of the municipal filter for the city of Lawrence, the first large filter constructed in America, and which up to the present time has undoubtedly saved thousands of lives in that city. The construction of this filter, according to the designs and under the direction of this department, started the movement throughout the country towards the purification of public water supplies by filtration.

Reviews of the work of this division have been given in different reports, and it is impossible in this space to give even the principal subjects studied. It might be mentioned, however, that in sewage purification the first 2-story tank for the treatment of sludge was put into operation at the experiment station in 1899, and was practically the same as the so-called Imhoff tank, now one of the principal features at many large purification works in this and other countries. The purification of sewage by the means of aeration and growths has its inception also at Lawrence in 1912, and now known as the activated sludge process, is being installed at many municipalities, especially abroad.

At the present time the principal sewage studies at the station are in regard to the improvements of the process just mentioned; upon the value of sewage sludge, and methods for its collection; in regard to the improvement of the efficiency of trickling filters, and upon what might be called concentrated methods of sewage purification.

In the treatment of water much work is being done upon methods for the removal of color, which, while efficient, will not increase the corrosive properties of water so treated; and recent investigations have been made in regard to the treatment of water by liquid chlorine and ultraviolet rays.

All the bacterial work of the department in regard to the water supplies of the state, rivers of the state, and the condition of shell fish from the different areas from which they are collected, is also carried on at this station.

The laboratories first established at the Institute of Technology, and for the past 23 years in the State House, are engaged, as previously stated, in examining chemically and microscopically the waters of the state of all kinds. This work has directly to do with all engineering investigations of the state of whatever kind, and furnishes many of the data necessary in making satisfactory replies to the several hundred applications made to the department each year for advice in regard to quality of water, improvement of water supplies, treatment and disposal of sewage and trades waste, etc. In these laboratories up to the present time nearly 150,000 chemical analyses have been made. Much field work has been carried on here in the direct examination of rivers, water supplies, the waste from factories and the condition of sewage areas.

Partial Assessment Method for Water Main Extensions.—The assessing of guarantees or what may be more properly termed partial assessments for water and gas main extensions has been in operation in Duluth, Minn., for the past 6 years. In his report for the year ending Dec. 31 last Mr. D. A. Reed, manager of the Duluth Water and Light Department, gives the following account of the working of the plan and the results obtained. Eight per cent of each extension cost is assessed annually against the abutting property to cover interest maintenance, depreciation and sinking fund charges. On these assessments is credited that portion of the gas and water rates paid by each customer on each parcel that is intended to cover the same items of expense. This is figured approximately as one-half of the water rates and one-third of the gas rates. Where credits in any case exceed assessments, the surplus is distributed over vacant property assessments and where the total credits of any extension exceeds the total assessments, all assessments for that extension are discontinued, otherwise they continue for 15 years. Automatically this throws the burden of extension upon the property benefited until it becomes self-sustaining by the consumption of gas and water. The property, however, is relieved as soon as there is sufficient consumption to pay approximately all expenses. The following table shows how this plan has worked out during the past six years:

CONDITION OF ASSESSMENTS FOR EXTENSIONS.

Started in.	No.	Discontinued.	In force 12/31/19.	Original Amount of Assessments	12/31/19 Amount Now in force.
1914	17	4	13	$ 1,498.32	$ 623.53
1915	59	19	40	5,763.44	2,893.67
1916	66	12	54	7,821.47	4,803.48
1917	48	2	46	8,496.98	5,613.06
1918	9	1	8	1,729.62	1,594.16
1919	19	0	19	5,679.12	5,462.92
Totals ..	218	38	180	$30,988.95	$20,990.82

How You Can Aid in Securing Nomination of Herbert Hoover

The Engineers' Hoover Committee of New York City has issued an open letter addressed to the engineers of America, setting forth the reasons why Herbert Hoover should be nominated for president. The letter follows:

> None of the undersigned has been active in "politics" heretofore; nor are we now! But we believe that our country needs just one kind of a man to guide its fortunes during the next four years.
>
> He should be a man understanding the underlying causes of the present nation-wide unrest—the economic as well as the social causes; a man who has administered large affairs successfully, handled vast sums economically and honestly; has employed laborers with sympathy and success; one having executive experience; who has made his way up from humble beginnings and therefore understands the psychology of the man who works with his hands; one who has the courage to combat squarely, whether in the board-rooms of corporations or in the councils of ignorant or vicious "Soviets."
>
> We need a man not only "favoring" economy in the National Administration, but an avowed advocate thereof, with the knowledge gained from experience of how a budget system is prepared and also how it should work; in other words a sane and tried "efficiency expert."
>
> America needs a man who has seen and knows actual conditions overseas and who can guide our international relations with firmness and sympathy, justice and honor; a man who has met face to face and understands those who lead the councils and influence the policies of European nations, new and old; who has had not only the grace to say "Yes," but the courage to say "No!" when necessary, not only to our late enemies, but to some others abroad who would take advantage of American sympathy or generosity—yes, and to some of the few here who would "profiteer."
>
> Some of us know and respect one or more of the men who are seeking in an honorable way to secure the presidential nomination, and others who are also favorably thought of; but has anyone of them the first-hand knowledge of our national and international problems that are in the undisputed possession of Herbert Hoover? We think not!
>
> We believe it is possible that he can be nominated, even without a political machine behind him; that the American people can constitute themselves a "Committee of the Whole" whose choice will be triumphant, provided the "vox populi" can be made audible.
>
> How can this be done? By bringing it about that the people shall not only speak out what we believe is in their hearts but that their voice shall be heard.
>
> We are members of one or another of the great engineering societies of America, but we have neither asked nor do we expect these organizations to act as such. But if each of you will constitute himself a committee of one, each in his own locality, to spread the well-known facts of Herbert Hoover's career, personality and attainments and to bring to the delegates of your own state the knowledge of your neighbors' demand that he shall be the nominee, this result will surely be attained. No one knows better than the political leaders of all parties that if nominated he is sure to be elected.
>
> Will you help to bring this about?
>
> ALBERT R. LEDOUX, New York.
> CHARLES F. RAND, New York.
> HOWARD E. COFFIN, Michigan.
> J. VIPOND DAVIES, New York.
> CHARLES T. MAIN, Massachusetts.
> HNTER MUcDONALD, Tennessee.
> B. B. THAYER, New York.
> J. G. WHITE, New York.

Following is a list of Engineers' State Hoover Committees. Anyone wishing information or advice as to ways and means should write to his State Committee or to The Engineers' Hoover Committee, 480 Lexington Ave., New York:

Addresses of Engineers' Hoover Committees.

Alabama—Richard M. Hobbie, Montgomery.
Arizona—Fred J. Elliott, Central Bldg., Phoenix.
California—Ralph Merritt, Sutter and Montgomery Sts., San Francisco.
Colorado—Lou D. Sweet, 1017 17th St., Denver.
Connecticut—480 Lexington Ave., New York City.
Delaware—480 Lexington Ave., New York City.
Florida—L. H. Haney, Southern Wholesale Grocers' Assn., Jacksonville.
Georgia—A. M. Schoen, Southeastern Underwriters' Assn., Atlanta.
Idaho—W. G. Jenkins, Jr., Boise.
Illinois—Robert Stevenson, Jr., care John Burnham & Co., La Salle and Monroe Sts., Chicago.
Indiana—Dr. H. E. Barnard, State House, Indianapolis.
Iowa—Hon. George W. Clarke, Des Moines.
Kansas—R. W. Hoffman, Enterprise.
Kentucky—Lafon Allen, 329 Guthrie St., Louisville.

Louisiana—C. F. Mock, 308 Whitney Bldg., New Orleans.
Maine—Judge Harold E. Cook, Augusta.
Maryland—John T. Stone, Maryland Casualty Co., Baltimore.
Massachusetts—John Richardson, Young's Hotel, Boston.
Michigan—Elbert H. Fowler, 801 Vinton Bldg., Detroit.
Nebraska—W. B. Tagg, 208 Bee Bldg., Omaha.
Nevada—Dr. H. W. Hill, State University, Reno.
New Hampshire—Huntley N. Spaulding, North Rochester.
New Jersey—Henry W. Jeffers, 505 Essex Bldg., Newark.
New York—480 Lexington Ave., New York City.
North Carolina—Calo K. Burgess, 609 Commercial Bank Bldg., Raleigh.
Ohio—Joseph C. Green, 204 Johnston Bldg., Cincinnati.
Oklahoma—M. J. Munn, Cosden Bldg., Tulsa.
Oregon—O. C. Leiter, 430 Morgan Bldg., Portland.
Pennsylvania—Charles J. Hepburn, 803 West End Trust Bldg., Philadelphia.
Rhode Island—Alfred M. Coats, 77 William St., Providence.
South Carolina—480 Lexington Ave., New York City.
South Dakota—D. P. Lemen, Sioux Falls.
Tennessee—Michael O'Grady, Chattanooga.
Texas—W. E. Wrather, 6044 Bryan Parkway, Dallas.
Utah—Judge H. H. Rolapp, 159 S. Main St., Salt Lake City.
Vermont—Frank E. Langley, Barre.
Virginia—Berkeley Williams, 8th and Main Sts., Richmond.
Washington—C. F. Riddell, Colman Bldg., Seattle.
West Virginia—M. A. Bratten, Marlington.

Tests of Plain Concrete Sewer Pipe

Recent crushing tests on plain concrete sewer pipe that has the outer surface corrugated, showed it to have a capacity in pounds per lineal foot of from 20 to 70 per cent in excess of the requirements of the American Society of Testing Materials. A paper read by E. P. Heywood, Assistant Engineer, Toronto Harbor Commission, before the Toronto Branch of the Engineering Institute of Canada on April 15, 1920, gives the following data on this kind of pipe.

This plain concrete sewer pipe was manufactured by the Independent Pipe Co., Ltd., at Woodstock, Ont., and is called the McCracken pipe. The purpose of the corrugations is to increase the crushing strength of the pipe. The following tests made by the Canadian Inspection & Testing Co., Ltd., show the qualities of the pipe:

CRUSHING TEST ON McCRACKEN PIPE.

Diameter, in.	Length, in.	Thickness, in.	Capacity in lbs. per lin. ft. (average).	A.S.T.M. requirements, lbs. per lin. ft.
6	25	¾	2,477	1,430
6	30	⅞	2,570	1,430
10	30	1	2,440	1,570
12	30	1⅛ to 1¼	2,235	1,710
15	30	1½	2,338	1,960

ABSORPTION TEST ON McCRACKEN PIPE.

Diameter, in.	Absorption.	A.S.T.M. requirements.
6	4.6%	8%
8	4.6%	8%
10	3.9%	8%

The pipe is cast vertically in a patent machine. A belt-driven vertical shaft revolves a number of packer rings slightly larger in diameter than the required inside diameter of the pipe. Immediately below the packer wings is a kind of piston called a packer head, which, on revolving, produces the smooth inner surface of the pipe. The strong centrifugal force exerted by the packer wings packs the concrete hard against the corrugated outer mould or jacket. Below the packer head is the bell packer, which forms the bell of the pipe. All the packers revolve at the rate of 350 r.p.m.

The concrete is fed into the jacket of the pipe by passing through a chute from an endless chain of buckets. When more concrete is added, the packer head and wings are gradually raised until the top or spigot end of the pipe is completed. No inner form is used, as the concrete is so densely packed, and of a semi-dry mix, that it perfectly retains its true shape.

When the pipe is made it is removed to a curing shed or kiln and the jacket removed. A system of sprinklers is operated in this kiln, and a mixture of water and steam, at 70° F., in the form of a very fine spray or mist, is allowed to fill the kiln for 30 hours, thereby procuring perfect hydration of the cement. After two weeks, the pipes are ready for shipment.

The pipe is made in sizes from 6 in. to 24 in., and has been used extensively in many Canadian works, including storm sewers for Toronto Harbor Commission and the cities of Guelph, Gault, Woodstock, Walkerville, London, Ontario.

Results of Activated Sludge Experiments at Milwaukee

During the past year, the operators of the testing station at Milwaukee, Wis., has taken up certain experiments and definite results on practically all of the problems have been obtained. In the Sixth Annual Report of the Milwaukee Sewerage Commission is contained the report on these experiments by the Chief Engineer, T. Chalkley Hatton. The following data from this report cover the principal results secured.

In the determination as to which was the most economical and best depth of tank, 10 or 15 ft., the experiments showed conclusively that, owing to the fluctuation in character and quantity of sewage, a depth of 15 ft. was necessary to prevent the light flocculent sludge, which settled slowly, from rising to the surface during a sudden increase of the flow of liquor. The ratio of diffusion plates was in favor of the 1 to 4.4 as against the 1 to 6.

Experiments indicated that it was possible to satisfactorily clarify the aerating tank liquor at the rate of flow from 1,600 to 2,000 gals of mixed liquor per square foot of sedimentation tank area when the tank was 15 ft. deep. 1.25 cu. ft. of free air per gallon of sewage treated were required. This quantity, states the report, will produce better than a standard effluent, but is necessary to prevent large masses from collecting on the surface of the filtros plates. The contact period ranged from about [illegible] to 6 hours. With properly baffled tanks, 4 hours on domestic sewage would probably be sufficient.

The volume of sludge produced from March 16 to July 15 was 12,100 gal. at 97.5 per cent moisture per 1,000,000 gal. of sewage. During this time, the raw sewage averaged 270 p.p.m. suspended solids, of which 3.5 per cent were removed by the fine screen. One hundred and seventy-five thousand gal. of sludge at 97.4 per cent moisture were returned to the aerating tanks per 1,000,000 gal. of sewage passed through. This represented about 16 per cent of returned sludge. With a 15-ft. deep sedimentation tank and a rate of 1,600 to 2,000 gal. of sewage per square foot of surface area, the moisture in the returned sludge will average from 97.5 to 98 per cent.

Experiments on sludge pressing were conducted with two types of filter presses and with several qualities of filter cloths, screens, plates, etc. One type was a vertical plate press made by the Simplex Ejector Co. operated to secure cakes from ¾ in. to 1¼ in. thick. The runs indicated securing an average of 3 lb. of sludge cake at 80 per cent moisture per square foot of filter cloth from sludge containing 87.5 per cent moisture in 4.5 hours. The high pressure required with this press was somewhat injurious. The other type was a platen press with racks between filter cloths made by the Worthington Pump & Machinery Corporation. An average of 68 runs gave 2.66 lb. of cake per square foot of filtering area with 81.5 per cent moisture from 97.8 per cent moisture in 5.38 hours. The sludge could then be reduced to zero moisture content without loss of the nitrogen content. Guarantees have been made to reduce the moisture from the sludge at the rate of 10 lb. of water evaporated per pound of combustible.

Odors in drying may be eliminated by passing the gases through a dust chamber and then through a spray washer.

Successful methods for eliminating the dust in the air used under the filtros plates consisted in drawing the outside air through a 10-oz. duct, then through canton flannel and finally through the hydro-turbo blower which washes and compresses the air at the same time.

The final design of the full-sized plant follows closely the results obtained in the experimental plant as outlined above.

Columbus, O., Plans $3,500,000 Waterworks Improvement.—Preliminary surveys have been started for a waterworks extension program for Columbus, O., calling for an expenditure of $3,500,000. John H. Gregory is consulting engineer.

Hetch-Hetchy Contract Let.—The Construction Co. of North America is reported to have been awarded the contract at $7,291,900 for completion of the mountain division of the Hetch-Hetchy water supply project of San Francisco, Cal.

Engineering Foundation Seeks Large Endowment

Based on the generous gifts and high purpose of Ambrose Swasey Engineering Foundation has since 1915 maintained a liaison between engineers, as represented by the founder and other societies, and scientific workers, as represented in National Research Council. Practical means for co-operation in research have been set up so that engineers in the numerous branches of the profession may join with physicists, chemists, geologists, geographers, psychologists, doctors, biologists, educators and anthropoligsts, in the attack upon problems of common interest and in the exchange of knowledge.

Potential benefits for the whole nation are very great, but these benefits cannot be gained without expenditure of effort and materials. Research workers must be supported. Equipment, materials, working places and traveling facilities must be provided. Since the benefits accrue to the professions, the industries and the public in general, support in large measure should come from general funds, such as those provided by endowments. Although engineers, like other professional men as a class, are not wealthy, some individual engineers have large means. Engineering Foundation seeks to build up its endowment to dimensions worthy of the profession. Engineers connected with industrial and financial organizations having great resources can aid by convincing proper officials of corporations that the continued prosperity of our industries depends upon continued progress of research. Since the commercial and industrial establishments of the country reap the larger proportions of the financial profits arising from scientific and technological work, these establishments should contribute liberally to the support of research.

Scientists are more largely concerned in research in pure science, the search for undiscovered knowledge for its own sake, the usefulness of which may not become apparent in some instances for many years. Between this most advanced line and the development of specific industrial devices or processes, lies the large field of research in applied science and the industries which especially concerns technologists. In this broad field there is scarce an item of work in which the engineer in some branch of his practice is not directly concerned. Sooner or later the engineer uses all the results of research in science and the industries.

There are many problems relating to the materials and forces of engineering on which further knowledge is needed. Progress will be made approximately in proportion to the funds made available. But there are other kinds of problems which concern the engineer. No longer may one declare, as did Professor J. B. Johnson, a generation ago, that "Engineering differs from all other learned professions in this, that its learning has to do only with the inanimate world, the world of dead matter and force." Many acute social and economic questions of our day need the dispassionate, impartial, patient study of scientists and technologists. To these questions must now be applied the scientific method of collecting facts by thorough study, and the engineer's capacity for planning and performing, instead of ill-considered "reforms."

Engineering works, public, corporate and private, frequently involve studies of special problems or in themselves constitute full-sized experiments, which could be made to yield important data for general technical use. Sometimes the engineers in charge do not perceive the opportunity, not having been trained in research work. More often the possibilities are realized, but means, men and time are not available because of the urgency for completing the project with a minimum expenditure in the shortest practicable time.

Occasionally experimental work is undertaken in accordance with a well-conceived plan as a necessary or desirable adjunct to the main operation. In such cases the exigencies of the main operation sooner or later interrupt the experimental work; or the men who have it in hand leave the force; or the information is gained, but never written up; or the statement is buried in some report of limited circulation; or greater familiarity with research methods and a broader conception of the problem could, with small additional expense, have secured much more valuable results and have made them more generally useful.

Again, many construction or manufacturing operations might be made to yield useful data of greater value than those obtained from small-scale laboratory experiments, if only trained observers with suitable instruments were provided. Often the expense would be slight. Sometimes for lack of trained observers occurrences of scientific significance pass unnoted.

The services described in the foregoing paragraphs, and many others, could be performed by Engineering Foundation, if adequate funds could be placed at its disposal. The Foundation does not plan to build laboratories and conduct research work directly, but rather to stimulate, co-ordinate and support research work in existing scientific and industrial laboratories, co-operating, insofar as many prove advantageous with the National Research Council.

Mr. Charles F. Rand of 71 Broadway, New York, Past-President of United Engineering Society, and of the American Institute of Mining and Metallurgical Engineers, was elected chairman of Engineering Foundation March 19, to succeed Dr. W. F. M. Goss, resigned. With the collaboration of Mr. Swasey, Mr. Rand is actively seeking additions to the endowment fund which will swell the total to at least a million dollars in the near future. Mr. Swasey's gifts amount to $300,000.

American Water Works Association Convention

The 40th annual convention of the association will be held at Montreal, Canada, Jan. 21-24, with headquarters at the Windsor Hotel. The tentative program calls for the following:

Monday, June 21: Registration, meetings of executive and other committees and informal get acquainted meetings in lobbies and exhibit rooms.

Monday evening: Informal reception arranged by the Local Committee and the Water Works Manufacturers' Association at the Windsor Hotel. Dancing.

Tuesday, June 22: Forenoon—Opening of convention in the convention hall at 9 o'clock; reading of papers; The Municipal Water Supply of Montreal, by Thomas W. LeSage; The Works of the Montreal Water and Power Company, by F. H. Pitcher; The Experience in Montreal in the Manufacture of Alum, by James O. Meadows.

Afternoon: The Water Works of the City of Quebec, by Arthur Surveyor; Water Supply Problems in the Province of Quebec, by T. J. Lafreniere; The Water Works of St. John, New Brunswick, by Frank A. Barbour.

Evening: Water Works Experiences, by Beekman C. Little; Economic Features of Pumping Station Operation, by Leonard C. Day; Difficulties in Building the Louisville Pumping Station, by James B. Wilson.

Wednesday, June 23: Forenoon—The New Water Supply of Winnipeg, by James H. Fuertes and William G. Chase; President's Address, by President Carleton E. Davis; Reports from Sections; Report of the Associations' Representative on the American Electrolysis Committee; Report of the Committee on Private Fire Protection Services, Nicholas S. Hill, chairman; Report of the Committee on Official Standards for Water Analysis, Jack J. Hinman, Jr., chairman; Report of the Committee on Standard Specifications for Cast Iron Pipe and Specials, Frank A. Barbour, chairman; Report of the Committee on Cold Weather Troubles, Charles R. Bettes, chairman; Reports of Officers and Standing Committees; Nomination of Members of the Nominating Committee. Selection of Place for Holding the 1921 Convention.

Afternoon: Entertainment by the Water Works Manufacturers' Association, probably a trip through the rapids of the St. Lawrence River.

Evening: A smoker for the men, given by the Water Works Manufacturers' Association, and for the ladies a theater or card party.

Thursday, June 24: Forenoon—Superintendents' day. Discussion of the selection, installation, reading and maintenance of water meters. The discussion will be opened by several papers on the subject by members of the association.

Chemical and Bacteriological Section: This section is preparing a program for a separate meeting Thursday. At this meeting a paper will be read by Colonel George A. Johnson introducing the subject of the quality of water.

Other subjects and papers for this section meeting will be announced later.

Afternoon: A general discussion of the legitimate uses of water, what they are and how to estimate them. There has been much discussion on water waste and how to prevent it, but up to the present time little on its legitimate use. Some cities have been criticized because of the high per capita consumption without knowledge of the legitimate uses of water in that particular place. The discussion will embrace private sources of industrial supplies; the nature of the demand for water by different industries, the actual demands of water for domestic consumption by families of different means.

Evening: Damage of Deep Wells by Sea Water, by Dr. William P. Mason; Cost-Plus Contracts in Water Works Construction, by George W. Fuller; Standard Forms for Contracts, by G. W. Buchholz; The Trend of Prices, by Leonard Metcalf.

Comparison of Pre-War and 1918-20 Costs for Concrete Lining for Irrigation Canals

Because of the demonstrated saving, in maintenance costs, as well as in water losses, the water users of the Orland Project of the U. S. Reclamation Service entered into a contract with the Secretary of the Interior in the spring of 1918 to line practically the whole distribution system with concrete This work involves 650,00 sq. yd. (25,500 cu. yd.) of concrete and covers about 70 miles of the canals and laterals. This work, of necessity, will be done between irrigation seasons, which will give a period of about 120 working days out of each 12 months.

A considerable amount of concrete lining had been constructed previous to 1918. In the April 12, 1916, issue of Engineering and Contracting a description of the work done up to February, 1916, was given. This article also included a cost analysis of the work. In the March, 1920, Reclamation Record, Mr. A. N. Burch, Project Manager, gives some interesting comparative costs for the earlier work and that done in 1918, 1919 and 1920.

The latter work was commenced in the fall of 1918 and is being pursued under limitations as to labor and funds. The methods in use are substantially the same as those described in the article mentioned above. The following tables give unit costs for the period previous to the fall of 1918, for the season of 1918-19 and for the first half of the season 1919-20:

	Prior to 1918.	1918-19.	1919-20.
Cement	$0.0977	$0.1200	$0.1260
Sand and gravel	.0424	.0535	.0643
Labor, preparing canal	.0691	.0738	.0853
Labor, mixing	.0301	.0392	.0293
Labor, placing	.0307	.0413	.0564
Labor, sprinkling	.0043	.0052	.0013
Engineering and supervision	.0292	.0230	.0259
Equipment maintenance	.0074	.0062	.0088
General expense	.0438	.0272	.0311
Total per square yard	$0.3547	$0.3894	$0.4284
Quantity, square yards	267,320	57,880	30,000

Based on 100 as representing costs prior to 1918 the following statement shows the relative cost of the principal items entering into the work:

	Prior to 1918.	1918-19.	1919-20.
Materials	100	124	136
Labor	100	119	135
Superintendence and engineering	100	80	89
Equipment maintenance	100	84	120
General expense	100	64	70
Square yard	100	110	121
Wages, laborers	100	146	160
Wages, clerical, engineering, etc.	100	120	135

It will be noted that the increased cost of the labor and materials entering into the finished work is 35 per cent, and that the increased cost per unit of work is 21 per cent, while the wages paid to labor in 1919 were 60 per cent and to clerical and engineering 35 per cent greater than for the period before 1918.

There was a decrease in unit cost in engineering and supervision and general expense, amounting to 11 per cent and 30 per cent, respectively, as referred to the earlier period, and to 51 per cent and 32 per cent, as referred to the 1919 work. The relative economy of 1919 results is due in a small measure to these last two items but in greater measure to better organization, most careful co-ordination of the different operations involved, and unremitting attention to details.

Mr. Burch finds that, individually, the average laborers now employed do not render as efficient service as was given during the earlier periods of the work. The labor turnover amounts to about 20 per cent per month, and with the exception of some of the old employes and skilled laborers services are more or less indifferent and perfunctory.

Municipal and Private Ownership of Waterworks in Pennsylvania

Although Pennsylvania leads all states in total number of waterworks it stands relatively low as regards municipal ownership of these works. According to the recently issued report of the Pennsylvania State Water Supply Commission of the 614 waterworks in the state only 26½ per cent were municipally owned. The following table from the report shows the ownership of water works in several states:

MUNICIPAL AND CORPORATE OWNERSHIP OF WATERWORKS IN VARIOUS STATES IN 1909.

State.	Municipal plants. No.	Pct.	Corporate plants. No.	Pct.	Total number of plants.
California	34	47	38	53	72
Connecticut	16	21	60	79	76
Kansas	131	86	22	14	153
Massachusetts	147	77	45	23	192
Michigan	*100	54	*20	11	*184
New Hampshire	50	49	52	51	102
New Jersey	58	35	108	65	166
New York	289	70	124	30	413
North Carolina	†36	55	†15	23	†65
Ohio	168	78	47	22	215
Oregon	3	..	§...	..	§...
Pennsylvania‡	133	23	455	77	588
Rhode Island	4	21	15	79	19
South Carolina	17	53	15	47	32
Vermont	17	..	§...	..	§...
Wisconsin‖	..	..	...	..	...
Total	1,206	...	1,016	...	2,277

*Sixty-four other plants in doubt, but believed to be owned by municipality.
†Fourteen other plants in doubt.
‡Pennsylvania had in 1915, 163 municipal and 450 corporate plants and one jointly owned.
§Not known.
‖About 50% by each.

In larger cities of Pennsylvania municipally owned waterworks are more common and the tendency appears to be, as cities grow, to acquire water systems. Of the 676 municipalities receiving public water supplies, 149, or 22 per cent, are served by municipal works; 479, or 71 per cent, by incorporated companies; 24, or 3.5 per cent, by mutual companies, partnerships or individuals, and 24, or 3.5 per cent, by some combination of the above methods.

While in number the incorporated systems predominate, municipally owned systems supply about 60 per cent of the total water furnished by public supplies, due to the large consumption in Philadelphia and Pittsburgh.

Incorporated systems in municipalities or portions thereof supply an aggregate population of 2,338,000, while 3,126,000 are supplied by municipally owned plants; but the number of communities served by water companies is greatly in excess of those supplied by municipal works. Municipal plants usually supply only one municipality, while a group of communities is often served through a single corporately owned plant.

Locating Leaks in Water Mains with the Geophone.—Very satisfactory results have been obtained with the geophone in attempts made to locate leaks in water mains. According to a Report of Investigations of the U. S. Bureau of Mines, the water circulating in the ordinary city main can be heard with the geophones when they are placed on the surface, 10 to 12 ft. above the pipe. In the business district of Pittsburgh one leak was located within a few minutes although the water department had been trying to find it for two weeks The leak could be heard from the surface from any point within a circle of 60 ft. in diameter, and was located in the joint of a "T" connecting a 10-in. with a 15-in. main. The geophones were also used successfully to locate a leak in a 1-in. pipe serving a residence. The geophone is an instrument invented by the French and used during the war to detect through the earth, the rapping and underground mining operations of the enemy. It was improved by the U. S. Engineers, and more recently has been further improved by the engineers of U. S. Bureau of Mines, and its use in connection with special sounds has been developed.

Personal Salesmanship*

By WILLIAM S. WOLLNER.

While statistics are not available upon which to base the assumption, it can be said with a degree of certainty that fully 90 per cent of all persons engaged in the practice of engineering are "employed" engineers. In this respect engineering differs from the other professions, as it is probably true that in all other professions, except chemistry, that considerably less than 10 per cent are directly employed by corporations or individuals. "Employed" as used in this sense is meant to cover men paid a fixed stipend for services regularly performed for the same employer.

It being a fact that practically all engineers must at some stage of their career seek employment, it seems logical to assume that a study of the ethics as well as the practice of the profession should include some thought as to the means for securing it. It is further a fact that as the profession of engineering has advanced, methods of employment have changed and that the methods now recognized as having been extremely crude, although they were commonly accepted 20 or 25 years ago, must necessarily be relegated to the limbo of forgotten things.

A few years ago an engineering organization required temporarily the services of a man to analyze and classify some figures with reference to costs. The position was advertised in the want columns of the daily newspaper and personal calls were received from several men who were interested in securing the position. As the salary offered was small, it was not expected that men experienced in the higher positions of engineering practice would apply, nor that the men who would apply would go to any unusual effort to secure the position. The employer was therefore somewhat surprised to have a man call upon him with his case as carefully prepared for presentation as if the position offered was a permanent one paying a munificent salary. This man presented a tabulated statement of his experience in positions similar to the one for which he was applying and attached to this statement were letters of recommendation from the men under whom he had worked in these positions. His case was so clearly presented that the position was immediately tendered him and accepted. The work upon which he was temporarily engaged having about come to its conclusion, this man stepped into the private office of his employer and said, "Mr. Jones, you were good enough to take me into your office temporarily and I hope that the manner in which I have handled the work assigned to me has been satisfactory. When I applied for the position I am now holding I hoped that it might lead to a permanent connection. As a matter of fact, that was the only reason I accepted the temporary work.

"While I do not think I violated your confidence by not telling of it at the time you employed me, I have been engaged as chief engineer on various projects and have had a well rounded out experience in many branches of engineering. I have taken the liberty of preparing this statement of my past experience and would like to leave it with you for a few days so that you may see what work I have done and am capable of doing."

He laid upon his employer's desk an envelope containing a synopsis of his education and experience with cross references to letters of recommendation, charts showing organizations of which he had been a part and showing his relationship to the balance of the organization, photographs of work he had designed and which had been constructed under his direction, and as a matter of fact, a complete record of his experience and qualifications. The employer was so well impressed with the way in which the man's case was presented and was so thoroughly convinced of the man's ability, that he made him a proposition with reference to permanent employment and compensation that was not only satisfactory to the applicant but resulted in far-reaching mutual benefit to both employer and employed.

In marked contrast to the foregoing is the case of a man who, a few days ago, applied for a position as an assistant engineer. He had learned of the vacancy and called upon the employing officer who assured him that he would be glad to give him the position provided he could prove his ability to hold it. The applicant thereupon told in a general way of 18 years' experience in engineering work but made no specific reference to positions similar to the one to be filled. The employing officer called his attention to this and the applicant responded, "Oh, I can fill the job all right, and if I do not make good you needn't pay me a cent." To say the least, the employer was not impressed with this argument, but being a kindly intentioned individual he endeavored to steer the applicant's presentation of his merits along the lines that would indicate his ability to qualify for the position. It seemed almost impossible to do this as the applicant would reiterate the number of years' experience he had had in engineering work and the names of men under whom he had been employed, but he persistently failed to mention definitely positions he had occupied similar to the one to be filled and the names of men who could certify as to his ability to fill this particular kind of position. The employer was satisfied that the man was trying to "cover his tracks" and that he had neither held a position of this kind nor, if he had done so, it had been with credit. He, however, took the trouble to refer to the former employers and learned that the man was an extremely capable and competent engineer of high character and fully dependable. On the strength of his inquiries, he placed the man in the vacant position and from the very start he proved a distinct acquisition.

This is a case where a man had the goods to sell but was unable to properly present them to his customer His customer who was in the market to buy, believed that the goods this man had to sell were those he wished to buy and only desired to be convinced by the salesman that his judgment was correct. The salesman proved entirely incapable of proving his goods and it was necessary for the purchaser to obtain recommendations from other users. The man first mentioned in this article realized the value of an attractive wrapper, prominently displayed goods, and recommendations from former users in such shape that the prospective purchaser could determine from their inspection and without further effort whether the product offered was what he was seeking.

We have sales engineers; why not engineering salesmen? The sales engineer is an engineer who by engineering argument can prove the merit of his wares. The engineering salesman should be an engineer who having his wares, engineering services, to sell can apply to the transaction the principles of high class salesmanship. It is probable that by the very nature of its practice, engineering will always be done largely by employed engineers, and this being a fact, engineers should know at least enough about the principles of salesmanship to sell their service in the best, highest priced market.

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*From the May Professional Engineer.

Estimated Cost of 2,500 K W Hydro—Electric Development

As indicative of the present costs of an hydro-electric development, the Electrical World of March 27, gives the following figures for a New England hydro-electric plant which is now under construction. The plant will have two 1,250-KW., 13,200-volt, three-phase, 60-cycle generators directly connected to two 1,500-HP. water wheels. The design includes provision in the building for a third similar unit to be installed later. The dam consists of a concrete core wall and earth fill, with concrete spillway and headworks, water being taken to the power house through a 78-in. woodstave pipe line about 8,000 ft. long. The approximate head on the wheels is 175 ft. In building the plant the size of generating unit was slightly modified and the plant location was changed by a few hundred feet on account of reservoir location difficulties, but the itemized estimate for the original design shown below is indicative of the present costs:

ESTIMATED COST OF DEVELOPING 2,500-KW. HYDRO-ELECTRIC SITE.

Dam, headgates, racks, etc	$127,500
Penstock, 78-in. wooden	120,000
Power-station building and fixtures (brick and concrete)	30,000
Waterwheels with governors and relief valves	36,000
Generators and exciters	24,000
Switchboard and wiring	9,000
Transformers	10,000
Transmission line connections	1,000
Total	$357,500
Contingencies, 10 per cent	35,750
Total structural cost	$393,250
Interest during construction, organization, legal expenses, taxes and insurance during construction, 15 per cent	59,987
Total ($181 per KW.)	$453,257

Windmills for Pumping

In The Times Engineering Supplement an article on windmills gives some interesting details respecting this source of power. An interesting account is given in the Journal of the Royal Agricultural Society for 1897 by Mr. A. Y. L. Morley of the installation of a windmill in order to provide an alternative water supply for the villages of Great Brington and Little Brington, near Northampton, where a population of some 632 had nothing but highly suspicious surface water for all purposes. By sinking they came upon a supply of deep well water at about 120 ft. depth, and having constructed a large reservoir—as it turned out, a much larger reservoir than was necessary—they put in a windmill and pump, and had all the pure water they wanted without interruption or hitch. Contrary to much other experience, the cost of repairs and attendance after some four years' working was practically negligible. Attendance and oiling is said to have been not more than 1s. 6d. (36 ct.) per week. The cost of the wind engine and steel tower was £275 ($1,300), and of reservoir, holding 30 days' supply, £530 ($2,575). The power developed by the engine varied with the velocity of the wind from 3 to 9 hp.

As to the power to be obtained from windmills, in these it has been found that a good 12 ft. steel windmill furnished from 1 hp. in a wind of 20 miles an hour to 1.4 hp. in one of 25 miles, while a similar 16 ft. mill would give under the same wind velocities 1.5 and 2.3 hp. respectively. To obtain this duty, the mill has to be raised well above surrounding obstructions, such as buildings and trees, and, in practice, it was mounted for this purpose on a 50 ft. tower. The weight of the 12 ft. mill, with its tower, was about 2,000 lb., and of the 16 ft. mill about 4,250 lb. Taking these figures to be typical, it is evident that, from the points of view at least of prime cost and of relation of output to bulk, a better result would be obtained from two 12 ft. mills than from one 16 ft.

Cost of Pipe Laying at Hartford, Conn.—Only a small amount of pipe laying was done during 1918 by the Water Department of Hartford, Conn., due to lack of building and absence of requests for extensions. The cost of this work was very much in excess of any previous figures of the department, due to high wages, excessive cost of materials and difficulty in obtaining proper labor. The following table from the report of Caleb Mills Saville, Manager and Chief Engineer of the Department, shows the average figures for costs in 1918 and the unit costs for previous years:

Size in.	Length laid 1918, ft.	Cost per lin. ft. Labor.	Material including cartage.	Total 1918.	Total 1917.	Total 1916.	Total 1915.
6	1,736	0.83	1.31	2.14	....	1.42	1.42
8	5,431	1.45	2.14	3.59	3.16	1.68	1.62
10	3,561	1.37	3.56	4.93	3.12	2.38	2.16
12	336	1.11	3.04	4.15	4.12	2.82	2.43
16	570	1.29	4.88	6.17	3.64	4.58	....

The 1918 costs are based on the following: Unskilled labor, average $3.50 for 8 hours; pipe, $60 per ton; specials, $110 per ton; lead, 9 ct. per pound; no overhead charges.

The following table shows relative costs before the war and at the present time:

	1918.	1915.	Increase Pct.
Labor, average of 45 permanent employes, per 8-hour day	$ 4.30	$ 3.00	44
Cast iron pipe per ton	65.00	23.00	183
Lead per 100 lbs.	7.15	3.95	82
Meters (¾ in.)	18.00	12.00	50
Valves, 6 in.	20.00	10.00	100
Valves, 8 in.	31.40	15.75	
Valves, 10 in.	49.00	22.50	
Hydrants 2-way	49.90	25.06	100
Hydrants 2-way steamer	54.75	33.40	
Hydrants 4-way	66.10	33.10	

Personals

C. T. Venable, an electrical engineer, has been appointed town manager of Bedford, Va.

W. W. Brigden has been appointed superintendent of the water and sewer department of Battle Creek, Mich.

R. P. Harrison, clerk of the U. S District Court at Muskogee, Okla., has been appointed city manager of Muskogee.

Standish & Allan, Engineers and contractors, 108 S. La Salle St., Chicago, announce the active association of Jerome F. Wilhelm, formerly of the Union Bridge & Construction Co. of Kansas City. The firm will continue to operate under the name of Standish & Allan Mr. Wilhelm was formerly in partial charge of the pneumatic work on the new railroad bridge over the Mississippi River at Memphis and later in full charge of the construction of the pneumatic piers in the Metropolis bridge over the Ohio River. He will be in active charge of all future pneumatic foundation work for the firm.

George J. Roark, general manager of the Chamber of Commerce of Beaumont, Tex, has been appointed city manager of Beaumont.

Edward M. Milligan has resigned as first assistant city engineer of Youngstown, O., to accept a position with the International Steel Tube Co., Cleveland, O.

W. A. Judd, formerly superintendent of water works of Mason City, Iowa, has been appointed superintendent of the municipal water and power plant of Dover, Ohio.

Selden P. Sears has resigned as assistant engineer of the water department of Hartford, Conn., to accept a position with C. W. Blakeslee & Sons, contractors, New Haven, Conn.

R. F. Kelker. Jr., Marshall D. Gates and Charles E. DeLeuw have organized the firm of Kelker, Gates & DeLuew, engineers, with offices at 111 W. Washington St., Chicago, Ill., and 325 Pekin St., Lincoln, Ill.

Announcement is made by **Langdon Pearse and Samuel A. Greeley** that Paul Hansen until now chief sanitary engineer of the Illinois State Department of Health, has become a member of their organization. The firm name will be Pearse, Greeley & Hansen and the general practice of hydraulic and sanitary engineering will be continued with offices at 39 West Adams St., Chicago. Mr. Hansen (M. I. T. 1903) has devoted his entire career to the practice of sanitary engineering. He has been assistant engineer to the Massachusetts State Board of Health; assistant engineer on the design and construction of the improved water supply and sewerage work for Columbus, O.; chief engineer of the Pittsburgh Filter Co.; chief engineer of the Ohio State Board of Health; and recently captain in water supply service with the A. E. F. in the St. Mihiel Sector. Mr. Greeley and Mr. Hansen will be active partners with Mr. Pearse as special consultant.

Luis G. Morphy, of 56 Nottingham Road, Brighton, Mass., has resigned as principal assistant engineer of the Boston & Albany R. R. to take a position with The Foundation Co. of New York City as its representative in South America. He sailed on May 5 from New York City for Lima, Peru, and La Paz, Bolivia, and other important points in South America. Mr. Morphy was born in Orizaba, Mexico, Dec. 4, 1876, and came to America as a young man, graduating in 1900 from the Rensselaer Polytechnic Institute at Troy, N. Y. Immediately after he went into the employ of the New York Central R. R. at Albany, N. Y., in the engineering department. After serving in Buffalo, N. Y., and New York City he came to Boston in October of 1907 as assistant engineer of maintenance of way and construction. He has been successively promoted to assistant to the chief engineer, designing engineer, division engineer and principal assistant engineer on the Boston & Albany R. R.

O. E. Carr, city manager of Springfield, O., has been appointed city manager of Dubuque, Ia. Mr. Carr was graduated from Allegheny College in 1900. From 1900-3, employed by the government in U. S. coast and geodetic survey work; 1903-5, employed by the Baltimore & Ohio R. R.; 1905-6, employed by the city of Pittsburgh on the construction of filtration plant; 1906-8, employed by the J. G. White Co. at Olonpago, Philippine Islands; 1908-9, employed by the city of Seattle on earth computation in reducing the grades in the business section; 1909-11, employed by the United Engineer Co. of Portland, Ore., water department, supervision of water main construction; 1911-12, employed by the city of Cincinnati, O., engineer in charge of the underground survey; 1914-16, employed by the city of Cadillac, Mich., city manager, in charge of the installation of the city manager form of government; 1916-18, employed by the city of Niagara Falls, N. Y., installed the commission-manager form of government; from 1918, employed by the city of Springfield, O., city manager.

Industrial Notes

A. B. Konsberg, railway equipment, has moved his offices from 226 S. La Salle St., Chicago, to 10 N. Dearborn St.

The F. N. Wilson Machinery Co., 320 West 35th St., Chicago, Ill., has added to its line of contractors' equipment by taking over the National Equipment Co., which manufactured the National derrick. These derricks will be continued in all sizes by this company, who also specialize in clamshell outfits for handling material.

E. G. Lewis, formerly manager of the Cleveland office of the Bucyrus Co., has been appointed central sales manager of this company with headquarters at 622 McCormick Bldg., Chicago. He will succeed E. C. Hingsten, who has resigned. The Cleveland office, which was opened by the company on Sept. 1, 1919, will be continued under Mr. Lewis' jurisdiction.

The Harrison Safety Boiler Works, which has been carried on for many years as a co-partnership by Jos. S. Lovering Wharton, William S. Hallowell and John C. Jones, has been incorporated under the laws of the state of Pennsylvania, charter perpetual, as the H. S. B. W.-Cochrane Corporation with the following officers and board of directors: J. S. Lovering Wharton, president; John C. Jones, vice-president and general manager; W. S. Hallowell, secretary and treasurer; Horace E. Sibson, general sales manager; Axel B. Wallem, general works manager. The corporation takes over, as of date Jan. 2, 1920, the entire business of the former firm, acquiring its assets and assuming its liabilities.

Trade Publications

The following trade publications of interest to engineers and contractors have been issued recently.

Meter Boxes.—H. W. Clark Co., 12th and Hudson Ave., Mattoon, Ill. 32-page bulletin relating to Clark system of meter housing.

Valves.—Golden-Anderson Valve Specialty Co., Pittsburgh, Pa. 176-page catalog illustrating and describing automatic cushioned valves for high and low pressure steam and water service.

Sewer Cleaning Equipment.—Turbine Sewer Machine Co., 195 11th St., Milwaukee, Wis. 72-page catalog on the Turbine sewer cleaning machine. Contains numerous illustrations and descriptions of the work accomplished by this machine.

Railways and Excavation Monthly Issue

ENGINEERING *AND* CONTRACTING

Published by Engineering & Contracting Publishing Co., 608 South Dearborn St., Chicago.

HALBERT P. GILLETTE, *President and Editor* LEWIS S. LOUER, *Vice-President and General Manager*
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The four rotated special monthly issues and 4 quarterly issues of E. & C. (52 in all) entirely cover the civil engineering and contracting field at $4.00 a year. Any one of the four special monthly issues may be subscribed for as a monthly at $1.00 a year. The special quarterly issues relate entirely to foreign engineering and construction practice. The *articles* in the first two issues of each month completely cover the municipal engineering and contracting field. The *articles* in the first and fourth issues of each month completely cover county engineering and highway engineering and contracting. The *articles* in the 3rd and 4th issues of each month completely cover steam and electric railway location, design and construction. See the "masthead" on the first page of the Weekly News Section for information about our weekly contract news.

Roads and Streets—1st Wednesday
(a) Roads
(b) Streets
(c) Street Cleaning
(d) Municipal Miscellanies
(e) Management and Office System

Waterworks and Hydraulics—2nd Wednesday
(a) Waterworks
(b) Sewers and Sanitation
(c) Irrigation and Drainage
(d) Power and Pumping
(e) Management and Office System

Railways and Excavation—3rd Wednesday
(a) Excavation
(b) Management and Office System
(c) Quarries and Pits
(d) Steam Railways, Construction and Maintenance
(e) Electric Railway Construction and Maintenance

Buildings and Structures—4th Wednesday
(a) Buildings
(b) Bridges
(c) Harbor Structures
(d) Miscellaneous Structures
(e) Properties of Materials
(f) Management and Office System

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What Is the Matter with Regulation by Utility Commissions?

This journal always has favored the regulation of railway and public utility rates by federal and state commissions. We still have hope that government "regulation" will save the country from government ownership, but we admit that the outlook is not bright. By and large, neither the public nor the railway and utility companies are satisfied with the results thus far secured under public "regulation" of rates.

In theory public regulation seemed ideal 15 years ago. In practice it has been so far from ideal that the whole plan is likely to be scrapped. Why? Most of the defects of public regulation of rates are traceable to the fact that the rate regulating bodies are not entirely free from politics and public opinion. It is noteworthy that in very few states do the utility commissioners average a tenure of office exceeding four years. But even where the commissioners do hold office long enough to become fairly well acquainted with the general principles of valuation and the ecomics of rate making, seldom are the commissioners free from the influence of public opinion. They realize all too keenly that if their decisions are not pleasing to the public, there is grave danger that they will lose their jobs. Inwardly they rebel against this situation, as any honest man would. But they would be more than human were they always to decide cases entirely regardless of personal consequences.

Among the fairest and bravest of public service commissions is the one now holding office in New Jersey. But because they have done their duty, the governor of New Jersey is conducting an investigation that is likely to result in their dismissal from office. According to newspaper accounts Governor Edwards of New Jersey is said to have proclaimed before his election his intention to remove the present public utility commissioners. Jersey City, whose street car rates have been raised by this commission, has brought charges against the commission, and now Governor Edwards is to act as judge in the controversy. Was there ever a greater travesty on justice!

Although it is seldom that a public utility commission has been thus forced to defend its acts before a prejudiced judge, this instance should serve to focus public attention upon the anamolous position of every public utility commission. Such commissions are essentially courts, and theirs is the dangerous duty of frequently rendering decisions that the public will not like. Yet no protection is given these commissions, to insure their always acting impartially, regardless of consequences. They lack the safeguards that the constitution provides for our federal courts.

Every public utility commissioner should be appointed for life and be subject to removal

E. *and* C. Now $4 a Year

The greatly increased cost of all items entering into the production of Engineering and Contracting makes it necessary for us to increase the subscription price to $4 a year. The specialized monthly issues can be subscribed for, as heretofore, at $1 per year. We have realized for some time that we would have to increase our subscription price but have delayed taking the step in the hope that changing conditions would make such action unnecessary. We are now obliged, however, in view of the increased scale of costs in all branches of our business to definitely announce the advance in subscription price to $4.

only upon impeachment charges brought before a court. In addition, no public utility commissioners should be eligible for public office for two years after resignation from the commission. Finally, every candidate for a commissionership should be required to pass a civil service examination.

The salaries of state utility commissioners should not be less than $25,000 a year.

In many of our states there have been and there are able and courageous public service commissioners. But the risk of losing their positions is so great, under present methods of appointment, that a far-sighted man is inclined to seek another job where risks will be fewer, the pay for services greater, and where charges of "crookedness" will never be heard. To have to raise the prices of things that the public uses is a thankless job. Small wonder, then, that many commissioners soon tire of it and resign.

We object strenuously to the oft-heard statement that the theory of rate regulation is admirable. It is not, and never has been admirable; for an ideal theory takes cognizance of all forces and conditions as they are, not as they are imagined to be. Public selfishness is one of the forces that is ignored under the present theory of rate regulation. With selfish stupidity the public rants against a 1-cent increase in a street car fare, entirely regardless of the justice of a decision under which such an increase is granted. Selfish demagogues play cleverly upon this weakness of the public, some of them urging public ownership of all public utilities, others promising to eject the utility commissioners from office. An ideal theory of public regulation of utility rates must, first of all, recognize the necessity of protecting the public against its own selfish stupidity.

This protection of the public is securable only through protection of its judicial bodies.

"Unmask These Political Hypocrites"

In testifying before the Illinois Public Utilities Commission recently Gen. Charles G. Dawes, head of the Chicago Central Trust Co., said:

> The serious situation as to street railway transportation into which the politicians have thrust the people by demagogery, claimed to be in the people's interests, is difficult to overstate. The time is approaching when business men must give some attention to unmasking political hypocrites and carry the fight of reason against them to a public which they are misrepresenting. It should not be difficult to explain to the ordinary man that a great business like the transportation of a city should be settled as the business interests of the city demand, and not in the political interests of those who temporarily happen to be in control of the administration.
>
> Having made the operation by private companies under reasonable rates impossible, it would seem to be the policy of the city government to take over the property at confiscatory prices if possible, and then to conceal the inevitable increase in the cost of transportation to the public by taking a part of it from them in the shape of a five-cent fare and the balance in the shape of heavier general or special taxes. The total confiscation of the interest of the secondary security holders, with the moral injury to the community ignored, would not, in my judgment, save the public one-half what these politicians and their methods will lose it.

Gen. Dawes spoke with special reference to the traction lines in Chicago, whose efforts to secure increased rates of fare have been resisted by the mayor and his associates. But Chicago is typical rather than exceptional in respect to the efforts made by local politicians to prevent public utility companies from securing a fair return upon the value of their property.

As another example, take the city of Pittsburgh, which has been fighting the fare increase given to the street railways by the Pennsylvania State Public Service Commission. Or take the case of Detroit whose citizens recently voted fifteen million dollars with which to build street car lines with which to compete with those of the Detroit United Railway.

Led by politicians of the most ignorant and demagogic type, the citizens of hundreds of American towns have been fighting every effort to secure adequate public utility rates, until, as Gen. Dawes testified, the credit of many utility companies has become so impaired that they are unable to secure new capital for badly needed betterments and extensions. He urges business men to "unmask the political hypocrites" who are destroying the value of the securities of public utility companies. Engineers should join in and lead the movement to secure, for all public utility companies, such income as will adequately compensate the present owners and attract new capital.

Unprofitable City-Owned Street Car Systems of San Francisco and Seattle

The city of San Francisco is served by 360 single track miles of railway, of which 64 miles are municipally operated. The city owns 195 electric cars, car houses, etc., but no power plant. The investment in this municipal plant is $6,900,000.

For the year ending June 30, 1918, the operating net earnings were $334,301; but for the year ending June 30, 1919, they were $104,040, after deducting 14 per cent of the passenger revenue as a reserve for depreciation, and after deducting $200,867 as an allowance for taxes such as a private corporation would have had to pay, but making no deduction for bond interest.

In short, for the last fiscal year the net earnings of this municipally owned line were only 1.5 per cent on the investment, after making allowance for taxes. But even this small margin of profit has probably disappeared, for beginning with the first of last July the wages of platform men were increased to $5 per 8-hr. day as compared with $4.50 previously.

The proponents of municipal ownership have repeatedly cited the experience in San Francisco as evidence of the desirability of municipal operation of street ralways. Now that the San Francisco experiment is failing to justify the hopes of the advocates of city ownership, there is left for illustration only one other large socialistic experiment of this kind in America, namely, the municipal railway of Seattle. But the city comptroller of Seattle has just issued a report that shows even worse financial results for 1919 than those of San Francisco. The comptroller shows that the net earnings for the last nine months of the calendar year of 1919 were $90,251 after deducting $499,173 for depreciation reserve. He calculated this depreciation annuity by taking 4 per cent of the physical plant other than land. The corresponding depreciation annuity of the San Francisco street railway is equivalent to 5 per cent of the cost of the plant. The city of Seattle paid $15,000,000 for the street railway system, which was the actual cost of the physical plant. Hence the net earnings for 1919 were barely more than one-half of one per cent, exclusive of any allowance for taxes that the city has lost as a result of buying the system from a taxpaying company. Since the city must pay $607,424 interest on the bonds for nine months, the taxpayers have actually suffered a deficit of $517,173, according to the report of the city comptroller. This deficit, as before stated, does not include the lost taxes on the street railway plant, nor does it include "some $35,000 of expenses for the railway department paid in 1919 out of the general fund" and not charged to railway operating expense.

The street railway department of Seattle is maintaining the pavements on the portions of the streets covered by the track, whereas the railway department of San Francisco does not bear this expense.

The city of Seattle owns and operates 230 equivalent single-track miles and 540 street cars. It owns nearly four times the track mileage that San Francisco owns, but the investment in the plant is only $65,000 per mile, as compared with $108,000 per mile of the San Francisco municipal system. The city of Seattle purchased the plant at a bargain price, for it would cost fully double what was paid for it to reproduce it at the prices of materials and labor that prevailed in 1919. Yet already some of the men who advocated the purchase of the plant are telling the people of Seattle that it was actually worth only about two-thirds what the city paid for it! Such are the methods by which they seek to escape public criticism for this municipal ownership fiasco.

Another method used in the attempt to conceal the actual deficits from city ownership of public utilities consists in asserting that the annual charges for a depreciation reserve are too high. To support this contention they point to the absence of depreciation reserves in the case of most railway companies. But they never produce any data whatsoever to show that current maintenance expenditures are sufficient to provide for retirement of plant elements due to inadequacy and absolescence. In fact they studiously avoid all the actual experience with such plants over a long term of years.

The non-existence of a depreciation reserve in the case of the typical street railway company is attributable to the fact that the net earnings have never sufficed to pay 6 per cent on the investment and leave any surplus from which the needed depreciation fund could be built up. This is the real reason why railway companies seldom have a depreciation fund.

Now that Detroit is about to spend $15,000,000 for a street railway system, we shall soon see a bigger financial fiasco than that of either Seattle or San Francisco. Detroit will build her street railways at more than double the prewar costs, and not even a 10-ct. fare will save the city from a heavy deficit. At first the true deficit will be concealed, because with a new plant the maintenance expenses will be low. Later on, as the plant grows old, these will rise. Still later there will be improvements that will result in scrapping plant elements, for which there will be no depreciation fund. This has been the economic history of private plants. It will be repeated in an exaggerated form with city plants. But the tom-tom will be sounded, excuses will be made, and the public will pay in taxes what it should have paid in car fares.

Quantitative Analysis of All Factors That Affect Average Prices and a Formula for Predicting Price Changes

To the Editor: I have on hand your article on the data published in your issue of April 7 inst. I have given this very searching study and hasten to congratulate you on having accomplished one of the big things of this world. You have added to the known truth of the world. You have added greatly to the honor and prestige of this country.

I have devoted 14 years to the study of finance cost analysis, etc., from the engineering (scientific) standpoint. The results are published in a book entitled Financial Engineering by myself, published by the John Wiley & Sons, Inc., and just about off the press. I have found, in this field, the same as you have, that the so-called economics of Ely, Fisher, Seligman, are an agglomeration of false theories—general rot.

I expect to make additions to my book on Financial Engineering during the next year. May I use the material of your article in my book with, of course, due acknowledgment? My work on Financial Engineering deals only with costs. I have avoided prices. Your work makes it possible to discuss prices scientifically. I congratulate you heartily. You have set a new milestone in knowledge. I hope that you will publish more detailed figures in the future for I know that the total labor required to win through to the conclusion you have reached must have been enormous.

O. B. GOLDMAN, Professor Heat Engineering,
Corvallis, Ore. Oregon State Agricultural College.

To the Editor: A strong desire to see the correct theory established leads me to write you again, though I do not wish to prolong the discussion indefinitely.

Economics is complex and intricate as appears when an explanation is sought for the outflow of gold which you ascribe in your article in the April 7 issue to the adverse balance of trade, but which I would explain differently.

But the point I wish to make in this letter is in regard to the effect of bank deposits on prices. Your argument, as I understand it, is: That to consider currency only gives a result that is in agreement with facts; that to consider bank deposits instead gives a result that is not in agreement with facts and is, in fact, greatly at variance therewith and is, therefore, incorrect and wrong. But if both currency and deposits are used, after decreasing the influence of deposits by reducing those figures by applying some coefficient, a fairly good result can be obtained as I will now show.

If, for example, per capita deposits are multiplied by a coefficient of one-fifth and added to per capita currency the resulting figures for the years 1885, 1900 and 1918 are as follows: 33.93; 45.98; 103.95, which are in the ratio of the numbers 73.8; 100.0; 226.0. The per capita currency figures alone are: 23.03; 26.93; 50.81, which are in the ratio 85.5; 100.0; 189.0. The year 1900 being taken at 100 in each case.

Then for the year 1918 the use of the former figures will give a higher result in the ratio of 226.0 to 189.0 or 19 per cent higher and 19 per cent added to 177 the index figure for 1918 as calculated by your formula gives the new index number 211, now the actual or true index number is 196 so that the result obtained when bank deposits are included is closer than when they are omitted. Similarly the index number for 1885 calculated in the new way is 76 while calculated from currency only it is 88, the actual figure being 86 the "currency only" method in this case gives the closer result. But it may be pointed out that if Dun's index number (75) be used as the standard for this year the new method gives much the closer result, while if the average of Dun's and the other index number be adopted as standard the new method is closer.

To summarize: If bank deposits are included with currency (first being reduced by the coefficient one-fifth) using the year 1900 as basis, the result for year 1918 is better, for year 1885 nearly as good (and taking Dun's as standard much better) and these three years fairly cover the range of variation of ratio of deposits to currency. So that the argument that currency only should be used because results so obtained agree with facts while results otherwise do not agree loses its force.

I do not pretend that the correct coefficient is one-fifth, or that that is the only one that could be used, possibly one-fourth would be nearly as good.

I only insist that the consideration of bank deposits is not necessarily excluded. JOHN WILKES.

Nashville, Tenn.

April 30.

On April 30, I wrote you in regard to your article on prices suggesting that by multiplying bank deposits by the coefficient one-fifth as good or better result could be obtained as by omitting deposits. That was purely empirical method. Thinking over the matter since and studying your article of April 7 it seems to me a rational basis for this is to be found in the two facts that checking deposits are only half of total deposits and that (probably) currency outside of banks circulates twice as fast as bank deposits. The first fact your article shows, the second probability may be inferred from your argument that the average payment period with circulating currency becomes fixed and is kept constant by workmen and their habits and considering that bank deposits tend to have their average payment period also fixed and that this period is likely to be longer, perhaps twice as long, as the workmen's period. This is rational since from the nature of things it takes longer to adjust the larger matters, for example purchase of goods by merchant which must be unpacked, examined, "checked," etc., or in the case of a real estate transfer, for instance, where title must be examined, deeds written, etc. The product of these two factors would give a coefficient of one-fourth; the outstanding difference might be made up in some such way as outlined in your editorial of May 5.

But why include bank deposits if same result can be obtained without them? Because some economists consider that they are effective as well as currency and because, if they are so, then if they vary while currency remains constant a better result will be obtained than by the use of currency alone. JOHN WILKES,
Nashville, Tenn. Civil Engineer.

You Have a Pair of Beam Compasses

By ARMEN AREND,
Assistant Engineer, Cincinnati, O.

Every engineer and draftsman has beam compasses. Let me assist you in assembling the parts.

Straddle your bow pencil near one end of a folding pocket rule, clamping bow with its own gage screw; similarly place bow pen near the other end of rule. The rest of the adjustments will be clear.

This improvised pair of beam compasses has given perfect satisfaction to writer.

Gasoline Loss Due to Improper Adjustment of Carburetors of Motor Cars.—Automobile exhaust gas tests now being made at the Pittsburgh station of the U. S. Bureau of Mines showed large variations in gasoline economy, due to the fact that the owners were running the machines with improper adjustment of carburetors. Most of them were using very rich mixtures. The average of 24 cars tested showed that 20 to 30 per cent of the heat in the gasoline went out in the form of unburned gases in the exhaust. In other words, if the mixture had been leaner, the owner would have gotten 25 per cent more mileage from a gallon of gasoline.

Book Reviews

Topographic Maps and Sketch Mapping.—By J. K. Finch, C. E., A. M., Assoc. Prof. C. E. and Resident Director of Summer School of Surveying, Columbia University in the City of New York. 175 pp. Illustrated. First edition, 1920. John Wiley & Sons, New York. $3.00.

Reviewed by H. J. Armstrong, Professor Railway Engineering, Armour Institute of Technology.

Among the many books written in connection with instruction in various branches during the preparations for the late war this one has recently appeared, and will commend itself to teachers and others as very well worth while. The book is divided into three main divisions: Map Reading, Sketch Mapping and Landscape Sketching. A contour map 18 in. by 22 in. in a pocket in the back cover is used to illustrate many problems in the text.

The author states that while the origin of the book was military, he believes that it will prove useful in connection with courses in Geology, Geography, or Map Work and Sketching given in the regular curriculum of colleges and universities. The point is well taken that for a proper understanding and use of maps only the simplest mathematical knowledge is required, for the experience gained in the war training showed that men with only elementary geometrical knowledge, after a little instruction, took great interest and did excellent work in sketch mapping, especially.

No pains were spared to make use of as much illustrative material as could be used, as a very noticeable feature is the great number of diagrams, figures and sketches.

A very valuable appendix to the book is a descriptive list of the principal topographic maps of the various countries of the world.

American Civil Engineers' Handbook.—By Mansfield Merriman, editor in chief, with eighteen associate editors, 4th edition, 1920; John Wiley & Sons, Inc., New York, 1,955 pages; $6.00.

This excellent handbook, as it is now called, has been thoroughly revised and enlarged, to keep pace with the advancement of engineering knowledge, and the editors are to be congratulated on the result of their efforts in thus bringing so near to perfection a handbook scarcely 10 years old. The matter which is entirely new consists in the following:

1. An appendix on colored paper devoted to mathematical tables.
2. Section 3A, devoted entirely to Electric Railroads and written by William A. Del Mar.
3. Section 17, devoted to Irrigation and Drainage, written by Horace W. King.

Appraisal of New York City Railways

The firm of Stone & Webster, under date of Jan. 1, 1920, made a report of its appraisal of the New York Railways system to Mr. J. E. Hedges, receiver. From the Electric Railway Journal we take the following summary:

NEW YORK RAILWAYS VALUATION SUMMARIZED BY SEVERAL ACCOUNTS.

	At pre-war prices.		At June, 1919, prices.	
	New.	Less Depreciation.	New.	Less Depreciation.
Land	$10,388,800	$10,388,800	$10,751,850	$10,751,850
Conustruction and equipment:				
Material and labor..	51,657,360	36,283,616	92,843,200	64,696,870
Contractors' services	3,967,028	2,924,655	6,995,479	5,160,715
General construction costs	8,918,004	8,395,526	14,219,916	13,554,413
Total	61,542,392	47,603,797	114,058,595	83,411,998
Organization prior to construction	8,392,475	8,392,475	12,476,025	12,476,025
Working capital.......	2,882,305	2,845,591	3,264,874	3,204,698
Total property used in railway operation...	86,205,972	69,280,663	140,551,344	109,844,571
Property not used in railway operation...	2,792,998	2,285,525	3,503,833	2,682,086
Total property.....	88,998,970	71,516,188	144,055,177	122,526,657

The appraisal does not contain any figures for the following items:

1. Going value of property.
2. Special value of land for railway purposes.
3. Profits of promotion.
4. Discounts on securities.
5. Special value of existing franchises.
6. Net investment in superseded property.

The appraisal covers land, trackage, miscellaneous buildings, such as power stations, substations, car-houses, etc., rolling stock, power and substation equipment, one double-track tunnel, the complete distributing and transmission systems and the shop equipment, tools, furniture and fixtures, etc.

Shrinkage of Embankments

The Committee on Roadway of the American Railway Engineering Association, as an appendix to its report at the March convention, offers the following information bearing on the above subject, as obtained from circularizing various railroads and from other sources:

Reliable information received from the Interstate Commerce Commission and from various railroads furnishing information to the Valuation Department of the Interstate Commerce Commission, show many and vastly different results in the shrinkage of embankment and swelling of excavation. Cases are cited showing the swell of rock excavation ranging from 6 per cent to 48 per cent.

The following statement summarizes the information received:

AVERAGE SWELL AFTER PLACED IN EMBANKMENTS.

17 cases solid rock excavation taken from South and West.	25.2
15 cases 90% rock 10% earth taken from South and West..	31.5
7 cases 80% rock 20% earth taken from South and West..	17.1
17 cases 70% rock 30% earth taken from South and West..	18.9
8 cases 60% rock 40% earth taken from South and West..	13.9
7 cases 50% rock 50% earth taken from South and West..	16.6
9 cases 40% rock 60% earth taken from South and West..	5.5
7 cases 30% rock 70% earth taken from South and West..	*3.0
7 cases 20% rock 80% earth taken from South and West..	*0.1

*Decrease.

These figures are substantiated by figures on granite excavation by the Central Vermont Ry. in Massachusetts, showing this granite to swell when placed in embankment 31.86 per cent to 35.8 per cent. The same road also shows a shrinkage of 12.27 per cent with stiff blue clay and 7.76 per cent on fine, dry sand when placed in embankment. The sections on this work were taken immediately on completion of the grading and before track had been laid. All the above work had been done by dumping from temporary trestle.

In 21 cases, covering the country generally and representing a number of localities, we get an average shrinkage of 10.4 per cent. In round numbers, 3,000,000 cu. yd. are represented in these figures. The height and weather conditions are not of record and the fills were constructed in various manners, such as dumping from trestle, teams and scrapers, steam shovel and dump wagons.

Practically all the material represented is clay mixed with sand in various quantities. As quite a number of fills were constructed by several different methods on the same fill, it is not possible to establish a reliable percentage of shrinkage for the different methods of construction, but the individual cases vary from 15.1 per cent shrinkage in an instance where construction was performed by cars and stationmen to a 1.8 per cent shrinkage in a fill built by teams and scrapers.

It would seem from the figures submitted that an estimated shrinkage of 10 per cent is the best that can be done when handling roadway construction of earth composed of clay and sand, common to nearly all localities.

Shrinkage or settlement, of course, will start at once after the material is placed in embankment, but will be much more rapid after traffic is turned over the fill. The investigations of the committee substantiate the rule that earth occupies less space when placed in embankment than before excavated and rock swells when excavated and occupies more space.

The general conclusions reached from the investigation are as follows:

(1) Figure a swell of at least 25 per cent for solid rock removed from excavation to embankment.

(2) Figure a shrinkage of 10 per cent on earth removed from excavation and placed in embankment.

(3) Excavation and embankment composed of both rock and earth in mixed quantities should be estimated proportionately, using above rules.

These rules should be used with care and judgment, as there is no way of evading the fact that shrinkage does not always occur to this extent or that more shrinkage may take place than anticipated. It is, however, well enough established by observation that it is fair and safe to anticipate these results in preliminary estimates.

Relation of Railway Terminal Problem to City Planning

An entire session of the 12th National Conference on City Planning, held last month at Cincinnati, O., was devoted to the relation of railroad terminals to the city plan. At the session a committee report was presented which brings out important features of this phase of city planning. The report consisted principally of a discussion by William J. Wilgus, Consulting Engineer, New York City. This portion of the report is abstracted below:

The railroad terminal problem may be said to embrace three separate and distinct phases: that having to do with passenger and freight traffic destined for local distribution; that dealing with direct movements to and from local industries and other facilities having their own side tracks; and that having to do with the interchange of traffic destined for points beyond.

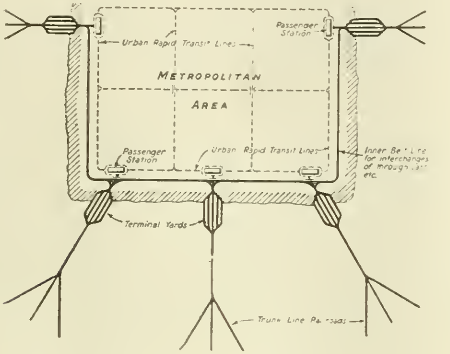

Urban Rapid Transit Lines
Passenger Station
METROPOLITAN
AREA
Passenger Station
Urban Rapid Transit Lines
Inner Belt Line for interchanges of through cars etc.
Terminal Yards
Trunk Line Railroads

Fig. 1—Arrangement for Inter-connection of Two or More Passenger Terminals by Urban Rapid Transit Lines.

In discussing the first of these phases, which has to do with the local distribution of freight and passenger traffic, it should be borne in mind that the railroad terminal is not such in the sense that the movement of either freight or passengers there terminates. The terminal is merely a step in the journey between the point of origin and that of final destination, where the passengers or freight are transferred from one means of transportation to another. Stated differently, the terminal is to be considered as a means of transition from one transportation agency to another. It is a terminal only for the vehicles employed in effecting a portion of the journey of their contents. The passenger, on arrival at the terminal, alights from his train and continues therefrom by vehicle or on foot to his residence or place of business; and the article of freight is transferred from the freight car to the truck that is to effect the final delivery.

In the early stages of the growth of the American city there were no rapid transit facilities to convey the passenger quickly and cheaply from the terminal to his home or place of business, and land for terminal purposes was comparatively cheap. Therefore the station was placed as closely as possible to the business center of the community. Similarly, the comparative cheapness of property, coupled with the slowness and limited radius of action of horse-drawn trucks, led to the placing of local freight terminals adjacent to the business center.

In the course of time conditions in these particulars have changed radically. Our cities have shown a remarkable increase in population, the property occupied for railroad terminals has become extremely valuable and is in urgent demand for civic expansion; streets have become congested with pedestrians and vehicles; rapid transit facilities for annihilating space have been installed in most of our large cities, and the slow-going horse-drawn vehicle has been largely replaced by the high-capacity fast moving motor truck.

In considering the solution of any given railroad problem it is therefore necessary to weigh carefully the arguments for and against the location of passenger and freight terminals as near as possible to the business center. The advantages are convenience to that portion of the traveling public which can most easily complete its journey on foot; and, in the case of freight, a slight saving in time and expense because of shortness of haul by motor truck between the freight station and the point of origin or destination. The disadvantages are the maintaining for railroad purposes in the midst of the city, of vast wastes which block orderly civic expansion and contribute largely to the congestion that increasingly is becoming such a fruitful source of delay, inconvenience and expense to the public.

If, as in the case of the Grand Central Terminal at New York, the railroad approaches and stations can be placed beneath the surface so that streets may be carried overhead without interference with the city's normal development, and if it is practicable to move trains by electricity so as to do away with nuisances incident to the use of steam locomotives and thereby permit the utilization of valuable "aerial rights" for revenue producing purposes, the better solution may be the placing of the terminal as near as possible to the business center. If, however, the underground treatment is impracticable and if the number of railroad lines and the shape of the city are such as to make undesirable this manner of solution, the course to pursue would be the banishment of the passenger terminals from the heart of the city to points sufficiently removed therefrom to afford ample space at moderate cost for the stations and yards, with contiguous parks, all planned in such manner as not unduly to interfere with future city growth.

An arrangement whereby two or more passenger terminals, thus located at points comparatively remote from the business center, may be inter-connected and also placed in close touch with all parts of the city by means of urban rapid transit facilities, is illustrated in Fig. 1.

In the case of local freight terminals the advantages of having them well removed from the business center would seem to far outweigh the small advantages of a shortened haul for the motor truck. The larger portion of the expense of freight distribution lies in delays to trucks awaiting opportunities for loading and unloading at the terminals, due to restricted facilities and congested surroundings. This situation is constantly becoming worse, and is contributing in a large degree to the high cost of living in great cities. Instead of continuing the journey of the railroad car as close as possible to the business center, with the attendant high cost of property and of operation, coupled with congestion and general inefficiency, for the sole purpose of shortening the haul by motor truck, it would be better to shorten the railroad haul somewhat, lengthen the haul of the motor truck, and place the points of interchange where cheap lands abound.

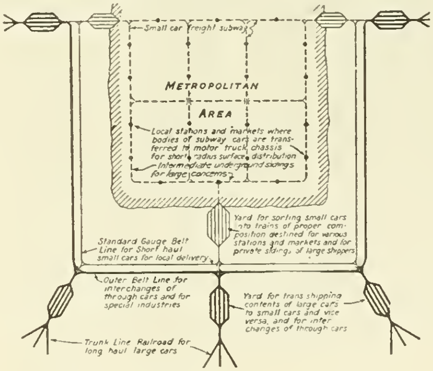

Small car freight subway
METROPOLITAN
AREA
Local stations and markets where bodies of subway cars are transferred to motor truck chassis for short radius surface distribution
Intermediate underground sidings for large concerns
Yard for sorting small cars into trains of proper composition destined for various stations and markets and for private sidings of large shippers
Standard Gauge Belt Line for Short haul small cars for local delivery
Outer Belt Line for interchanges of through cars and for special industries
Yard for trans shipping contents of large cars to small cars and vice versa, and for interchanges of through cars
Trunk Line Railroad for long haul large cars

Fig. 2—Small Car Freight Subways for Moving Freight.

In communities where the streets are broad and not overcrowded, it would be possible to continue freight distribution by means of motor trucks, but where surface congestion makes this course undesirable small car freight subways, as illustrated in Fig. 2, should be created, in which the freight would be moved by electrically-operated multiple unit trains of cars having a capacity of say 10 tons, from the trans-shipping points on the various railroad lines, through "gridiron" sorting yards, and thence beneath the city streets to a multiplicity of points throughout the city where mechanical devices would transfer the removable car bodies from the subway vehicles to the chassis of motor trucks for short-radius surface distribution, in a manner similar to that now in vogue at the Norwood substation of the Baltimore & Ohio R. R. in Cincinnati.

This arrangement, offering as it does all the advantages of the American type large-capacity car for long hauls and of the European type of car of moderate capacity for short hauls in cramped quarters, would mean diffusion instead of concentration of freight deliveries, and in so doing would solve the market problem and enormously reduce terminal costs and delays through centralized control and the employment of labor-saving devices.

There still remain to be considered the phases of the railroad problem which have to do with the placing of cars on the side tracks of private industries and waterfront facilities at or near the business center; and also means of interchange between carriers for the kind of traffic that is destined for points beyond. These needs as a rule are best met by means of belt lines, an inner one for local interchanges and an outer one for the bulk of the traffic that should be excluded from the congested regions of the city. The majority of the large cities of the country are already served with inner belt lines, and many of them also have outer ones. Both are highly desirable, not only from the standpoint of interchange of passenger and freight equipment, but also for the proper development of large industrial enterprises and for the unrestricted and prompt movement of military trains in time of war.

An example of the evil effects that flow from the lack of adequate inner belt lines and of a comprehensive outer belt line, is that of Greater New York, where the absence of these facilities is a growing menace to its commercial supremacy and to its safety in time of war. In fact, the experiences of the World War demonstrated that the latter defect bore heavily, not alone on the local community, but on the nation at large, through gross delays and confusion in the embarkation of troops and supplies.

Summarizing, the railroad problem in its relation to city planning should be treated in the light of the situation as it exists in each community, due weight being given to the following considerations:

Passenger and freight terminals for serving the community should be so located, in liaison with suitable lines of urban distribution, that the business and residential sections will be given ample opportunity for healthy expansion, that congestion will be avoided on the city streets, that full opportunity will be given for the aesthetic development of the community, and that delays and costs to the public will be reduced to the minimum.

Inner belt lines should be provided for the convenient placing of cars on private sidings of industries located where labor is readily accessible, and on tracks serving the local water front; and

Outer belt lines should be created for the speedy and economical interchange of through freight and for access to water terminals lying outside of the city proper.

It should be added that of course grade crossings, in the interest of both safety and economy, should be avoided to the fullest extent.

Accidents in Open Pit Mining.—The accompanying table, rearranged from a recently issued Technical Paper (Metal Mine Accidents in the United States During 1918) of the U. S. Bureau of Mines, shows the fatalities and injuries in open pit mines, where the ore was mined by steam shovels:

	Killed, per 1,000, 300-day workers.	Injured, per 1,000 300-day workers.
1914	2.73	261
1915	3.16	251
1916	3.15	282
1917	2.81	221
1918	3.66	214

The principal causes of the 39 fatal accidents in 1918 were as follows:

Falls of rock	11
Explosives	9
Haulage	13
Falls of persons	1
Miscellaneous	5

The above figures are based on returns from mines using the open-pit method of mining with steam shovels and representing typical companies employing about 10,000 men. These mines include many of the large open-pit iron mines of Minnesota and Alabama and the copper mines in Nevada, New Mexico and Utah.

Should Each Generation Bear Its Share of Depreciation Costs?

In a paper presented recently before the Western Society of Engineers, Mr. John Jirgel of Hagenah & Erickson, Chicago, gives the following reasons why he thinks the answer to the above question can be made in the affirmative:

(1) Because each generation and in fact each year and month within each generation is responsible for the using up of property in direct proportion to the demand which it makes upon the service.

(2) Because at any given moment the investment in a utility must be found intact so that transfer of ownership will not result in loss to any of the parties; and

(3) Because it is only in this way that continuity in service is guaranteed.

The matter following is reprinted from his paper:

The analogy between the use of coal and the using up of property has often been employed in connection with the subject of equalizing depreciation charges. The former is used up in one round of production while the latter is utilized for many such rounds. The time element constitutes the only difference in extent of utilization. If, then, present or past consumers of the service have used up the property, they alone should be accountable for that portion of the depreciation which has been incurred in rendering them service. To defer or shift any part of this burden is to permit in effect the use of part of the service without compensation. Equity, therefore, demands that each consumer in each period of each generation shall bear his full share of the maturing or accruing depreciation. In other words, depreciation must be provided for currently.

This current provision has an important bearing on our whole transportation problem. Our corporate form of management is such that the investors in any undertaking are constantly shifting. Especially is this true of that portion of the investors which is in active control of the management. If accrued depreciation is not provided for currently there is always a question as to whom is responsible for the shortage. If dividends are declared before depreciation is provided for, then the more conservative stockholders who follow in control must not only make the depreciation allowance for which they are responsible, but they must also provide for the shortage in the depreciation reserve as well. The public deals only with the property as a continuing entity and, therefore, is not concerned with changes in management in so far as such changes affect responsibility for depreciation allowances. To the investor, therefore, the current reservation for depreciation is exceedingly important for it is only in this way that his investment is protected.

This situation is more fully appreciated at the time condemnation proceedings are under way. When the property is taken over by the public the present value determines the price to be paid for such property. Whether we agree that this is the proper basis or not, the actual facts are that the commissions consider that accrued depreciation is deductible in determining value for condemnation purposes. If this is so, then the investors in the property at the time of public acquisition must either have the accrued depreciation provided for or they must accept a purchase price which will not represent their full investment. From what has been said above it is, therefore, highly important that at any given moment the investment shall be found intact and this end can only be attained by means of an allowance for depreciation provided for currently.

By far the most important reason why each generation should bear its share of depreciation is that it is only in this way that service can be made continuous. As stated above the setting aside annually on a life basis of an amount for the depreciation of any given unit provides a reserve which, when the unit goes out of service through the action of the agencies of depreciation, permits of its replacement. In other words, continuous service cannot be guaranteed unless provision for continuation is made in advance. The present generation, therefore, not only pays for the depreciation for which it is responsible, but also insures continuous service for itself and for future generations.

The difference between providing for each generation's share of the depreciation cost and providing for continuity of service is that the former implies depletion, while the latter recognizes that the service is permanent. The importance of continuity of service is lost sight of by those advocates who recognize in matured depreciation the only loss in value which has taken place. They neglect the important factor that when this year's earnings are not sufficient to provide for renewal expense there is no other provision by which such expense can be met. To defer such renewals; that is, do one part one year and another part the next, only results in poor service.

When large scale renewals are being considered, as if often the case with street railways, to defer payment amounts to financing in anticipation of some future contingency—the contingency in such case being that enough revenue will subsequently be earned to care for present renewal obligations. This, it appears, would be an unsatisfactory financial expedient and would in all probability find little favor with bankers. The only satisfactory method, therefore, is to insure continuity of service by providing for depreciation in advance.

In summary of what has been said above it may be stated that depreciation should be provided for currently because it is incurred currently, and because it is only in this way that the investment can be kept intact and continuity of service for the present and future generations assured.

But the argument may be advanced that granting all this the situation may still obtain that a utility has been unable to earn sufficiently to provide for any but maturing depreciation. If this fact can be established it would seem that the rate making base would have to ignore the depreciation element or provide for an allowance by way of going concern value. This argument obtains only in cases where commissions have established depreciated cost as the most important evidence of value.

During the past year increased consideration has been given to cost of reproduction, new and original cost as the most important evidence of value while the advocates of depreciated cost appear to be losing ground. The tendency appears to be toward an annual allowance for depreciation based upon the sinking fund method with undepreciated cost considered as the most important element in value determination.

To those commissions which consider accrued depreciation in valuation matters it is important to submit evidence as to whether depreciation has in fact been earned, and this can only be done by an examination of the records covering the entire history of the property. The importance of such examinations is not fully appreciated at the present time. The utilities are inclined to the cost of reproduction as their best basis for valuation claims. The historical data are considered as secondary and very often ignored. The commissions passing on these matters must often content themselves with mere statements of historical facts without much in the way of exhibits and quite naturally because of the intangible character of such statements they choose to ignore them.

When the historical facts are available it is a simple matter to make a yearly allowance for depreciation such that when the renewal and construction charges which have been incurred are taken into account there is left an amount which represents the accrued depreciation either on a straight line or a sinking fund basis, the basis used depending upon the theory of value held by the regulating body. In order to avoid distinguishing between repair and renewal charges the yearly allowance made should be sufficient to cover both items. This is more in accord with present day street railway accounting practice and has the advantage of eliminating all disputes on the method of handling maintenance and depreciation items in the past. If one allowance is made to cover both items all charges of whatever nature which have to do with maintaining the property in service condition can be made against such allowance.

In conclusion I may be permitted to emphasize that it is highly important in matters involving depreciation and valuation to have historical facts at hand so that claims with reference to the property can be definitely substantiated. Old records which may appear to have little connection with present investigations may be useful in settling matters now very much in dispute.

Sawn Ties and Future Cross-Tie Prices

Is the hewn tie to be replaced in the future by the sawn tie? Is it feasible and economical to manufacture sawn ties with a portable sawmill? Is tie timber to be subject to the same relative increased cost as practically all other timber?

An attempt to answer these and other questions relating to the tie supply of the future has been made by Mr. R. J. Witherell in a paper read before the recent annual meeting of the National Association of Railroad Tie Producers in Chicago. The experience of Mr. Witherell's company is quoted as follows:

"Although never a strictly tie-producing company, we have always aimed to cut our timber into the commodity producing the most value. Formerly we had a good many ties hewed from trees of the proper size, but where we have saw mills installed to handle a tract of timber, we find it can be handled much more economically now, and with a great deal less waste, by sawing everything that is large enough to produce a 6 by 8-in. tie and larger.

We found that there had been not only a great deal of waste of timber in the hewing, but also a great waste of energy in hewing the cuts that were considerably too large for a tie down to their proper size. In sawing the ties we find that we will get about 20 per cent of their value in tie siding, which, in hewing, would be wasted entirely. We also are able to produce a better and more uniform tie, and also eliminate the loss in count which we have always had with hewn ties on account of their being left in the woods after being taken up and paid for. One can go through any piece of timber from which ties have been hewn and find a good many old, rotten ties scattered here and there through the timber, which, in the aggregate, represented a big loss to the large producer. When ties are sawed and put out on the mill yard, there is no chance for this shortage to occur.

There are other reasons why we have found it necessary to saw more of our ties from year to year. One of the principal of these is the fast disappearance of that old-fashioned tie backer, who has had so much to do with building and maintaining our great railroad system. Men nowadays will not do this kind of work if they can get anything else to do, and when one can get them to do it they ask a price for their work that is often in excess of the cost of sawing; besides there is salvage from the waste. We know of as high as 45 ct. being paid for hewing white oak, 6 by 8-in. ties.

There is another feature of the case which is brought to mind very forcibly as soon as one commences to saw ties: First, the great amount of waste that is occasioned where ties only are cut, even from cut-over timbers, on account of tie logs having to be cut in our territory practically all in multiples of 8 ft. There is a large percentage of the logs that should be cut 10, 12 and 14 ft., to utilize the full length of the trees. This, together with the tie siding, will make the timbers turn out practically double the material when sawed, as against hewing.

Just as soon as one starts to saw ties, he changes the whole nature of the operation, for this brings the ties in direct comparison and competition with lumber, and one soon learns that only the rough top logs and the hearts of such logs as will work to tie lengths without loss can, with any reason, be put into ties.

It is the history of big hardwood tie production that it thrives only away from the saw mill, and any attempt to run them together always results in a big decline in tie production, unless values and all rules of conservation are ruthlessly ignored.

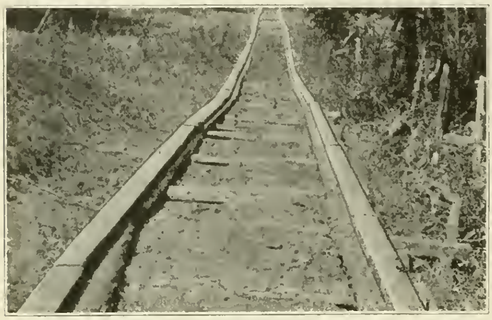
Continuing, Mr. Witherell gives examples of the value of tie timber when cut into 1-in. boards. It takes a log about 10 in. at the small end to make a good, clean 6x8-in. tie with a full 8-in. face. In Southern Illinois an oak tie would bring about $40 per 1,000 ft.; in Missouri and Arkansas about $30 per 1,000 ft.; while 75 per cent of the same logs cut into 1-in. lumber would give six pieces of 1x6x8 ft. grade lumber, 24 ft., worth at least $80 per 1,000 ft., or $1.92; and two pieces of 1x6x8 ft., $3, 8 ft., worth $30 per 1,000 ft. or 24 ct., or a total of $2.16, which is very nearly $1 more than the same stick would produce if cut into a tie. To make the example a little more definite, we could take 50 per cent of the ties as they run, resaw them into 1-in. lumber and produce 16 ft.

of good lumber, leaving a piece 3x6 at the heart. Figuring this on the same basis as above, a tie would produce $1.55.

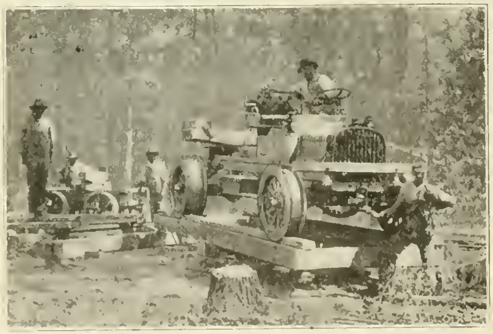
Then we have the car material and sound, square-edged timber proposition to figure against the production of ties. These run largely 10, 12, 14 and 16-ft. lengths and, being near squares, cut out to better advantage than ties. The price on this kind of material very closely follows the price of No. 2 common oak, which is today worth $100 per 1,000 ft. Oak timbers for construction purposes are bringing near this price, while car material is bringing only from $60 to $70; the price is bound to go up very close to the price of No. 2 common oak, as the values are approximately the same; and timbers of this kind cut into 1-in. oak will about average a grade of No. 2 common, so it is bound to have a decided effect on the price of ties in the near future.

Motor Truck Railroad for Lumbering

A motor truck with flanged wheels, operated on a wooden rail track is used by C. W. Stallworth, a lumberman of St. Stephens, Ala., for hauling yellow pine timber from his mill to the river, down which it is rafted to the market. The track is shown in the illustration. Wood slabs are used as crossties, and on these are nailed rough slabs, to which are spiked the 4x6 hardwood pieces forming the rails. The track is 2⅛ miles long. At each end is a turntable made by mounting a worn-out circular saw upon a stump, making a frame the exact length of the trunk, and mounting this upon another old saw. The turntable is so well balanced that one man can reverse the empty truck. A trailer, which also has railroad style flanged wheels, is used with the 2½-ton U. S. motor truck. The mill has an output of 50,000 ft. of yellow pine per day. Loads consisting of several timbers 18 in. square and from 18 to 40 ft. long are being hauled over the track, as many as 25 round trips being made per day.



Wooden Rail Tracks for Lumbering Operations.



Turntables for Reversing Motor Truck.

A Correction.—In the Acme Motor Truck advertisement in our May 5 issue showing an Acme truck and semi-trailer loaded with tarvia barrels, it was stated in the text that this truck was owned by Allen County, Michigan. This should have been Allen County, Indiana.

Determining Capability of Contractor by Standard Ratings

The classification of contractors by standard ratings as a means for stimulating efficiency is proposed by Mr. Leonard C. Wason, President of the Aberthaw Construction Co., Boston, Mass., in an article in the May Bulletin of the Associated General Contractors of America. He writes:

Making preparation for things that do not happen usually implies waste—sometimes waste of energy, sometimes waste of both energy and money.

Maintaining an organization to attract business only a fraction of which is eventually secured is a necessary process, yet it contains elements of waste. Ordinarily this waste is not considered serious if it bears a sufficiently low ratio to actual sales. But, as the ratio increases, there must come a time when selling costs will constitute an intolerable burden of overhead expense.

Without carrying this part of the discussion further, it will probably be admitted that, if that part of selling—or business-getting—which consists of barking up empty trees, could be eliminated, or materially reduced, much waste would be avoided.

These considerations hold particularly in the case of construction enterprises. He would be rash who would attempt to guess the amount of fruitless expenditure on the part of contractors in the preparation of estimates and proposals for work—especially public undertakings, that is never awarded them. Their only means of gaining consideration is to go through the formula, knowing all the time that the engineer in charge always may rule out a favorable proposal on the ground that the contractor making it is probably incapable of meeting all the obligations entailed in his offering.

Avoiding Waste Through Classification.—Under existing circumstances the right to reject any proposal must, of course, reside with the engineer in charge. Yet waste would be avoided by restricting the competition in advance to contractors who can render satisfactory proof of capability for the type and magnitude of the work to be undertaken. Such capability should be immediately determinable in accordance with a system of marks or ratings which a board of engineers and contractors could, without much difficulty, devise.

Given a task of known magnitude, it is a simple matter to compute the amount of liquid capital which a contractor must eventually command in order safely to assume the operation. By the same sign, when the nature of a large work is clearly understood, it is foolish to consider—even in theory—placing it in the hands of a contractor who is unable to supply adequate proof of special experience on his own part and on that of the supervisors in his employ.

The item of "plant"—equipment—is of constantly increasing moment. What kind of plant, and in what quantity, does the projected development require? Does the competing contractor own this equipment? If so, in what condition has he maintained it? If not, how and where does he propose to get it, and what assurance has he that he will not be disappointed?

Insuring the Existence of the Essentials.—Eliminate any one of the factors, capital, experience, equipment, and the multiple—satisfactory accomplishment—can never be obtained. That is virtually self-evident. The advisability of insuring the existence of the factors before talking of setting them into operation seems equally clear. If the suggested system of marks, or ratings, were in active existence, the engineer in charge of work on which proposals were to be invited would announce at the outset the limits of ratings within which the proposals of competing firms or individuals would receive consideration.

Such a definition of terms would rid the competition of the purely speculative and irresponsible bidder, as well as of the honest but over-optimistic seeker after business. In so doing it would relieve the engineer of the grave responsibility of rejecting certain bids solely on the basis of his judgment, or of general report. It would have the further advantage of bringing the bidding contractors to a clearly understood common denomination of ability and intention that would make comparisons of their proposals a simple one. In a larger proportion of cases than under existing methods, the award would go to the one making the most attractive offer.

If we ever reach the point of specifying the qualifications of contractors instead of stopping at the specification of materials and processes, we may, perhaps, hope to see adopted the device of making payments to contractors to cover the cost—often extremely heavy—of preparing their estimates. It is a cost that must be met by some one—in the first instance the contractor. But he, in due course, dilutes it through the profits of the jobs that he obtains, thereby making them pay toll to the jobs that he loses.

A Method of Guaranteeing Skill, Integrity, and Responsibility.—Here then is waste:—waste much of which is avoidable by the comparatively easy and completely honest process of rating contractors according to proved qualifications. Nothing invidious is implied in this process, nor is there anything in it to prevent the contractor from securing added recognition as it is due. It would, indeed, stimulate effort by recording growth through various stages, each carrying its virtual guarantee of capability. Hence, in accomplishing an economic good, it would, in addition, achieve the ethical good of raising the whole tone of the contracting business from that of a too often uncertain trade to that of an honorable profession.

Core Boring Records in New York City

A committee of the municipal engineers of the city of New York began the collection and classification of all the available core boring records, samples, maps and pertinent data some time ago and this collection is now housed on the 34th floor of the Municipal Building, New York City, and is open to anyone to whom the information may be of use upon application to Nelson P. Lewis, Chief Engineer of the Board of Estimate and Apportionment, Room 1347 Municipal Bldg.

The association of municipal engineers has prepared through its committee two information bulletins in order to expedite the search for any data desired, as well as for the interpretation of the data. These bulletins have been printed in the Journal of the association. A third bulletin in a recent issue of the Journal relates to consideration of the methods of making borings, boring records, observations and tests, together with suggestions about interpretation. In an introductory paragraph it is stated that the city of New York and private enterprises in the city and vicinity have probably spent no less than $3,000,000 for exploratory borings. As it is realized that comparatively few engineers have had wide enough experience to have met all the great variety of factors which must be considered in connection with the interpretation of data, a memorandum of an elementary sort which undertakes to enumerate the points of importance has been prepared and constitutes the above mentioned third bulletin. It is hoped that this will be helpful to engineers engaged in making borings, as well as for the interpretation of data already obtained.

Knowledge of Business Methods Essential to Large Achievement of Engineers.—When John Hays Hammond was asked what education he considered necessary for success in the field of mining engineering he answered that any of the good mining engineering schools provide the requisite preliminary training necessary for success and he added with emphasis that this was only true as far as education itself went as a factor. Much depends upon the individual. He also remarked that a commercial course should be included in the curriculum of a mining engineering course as a knowledge of business methods is indispensable to the large achievement of the engineer. This is more true of mining engineering than probably any other profession and part of Mr. Hammond's great success can be attributed to his keen business sense. His is a rare combination of business and engineering talent. But one must not fail to understand that Mr. Hammond is first an engineer, then a business man. Another important point for consideration is that the education of a mining engineer does not end when he receives his diploma. In fact it must continue for several years after this in actual service before a man is able to qualify for a real position and take his place among the seasoned engineers of the profession. The young man leaving college must enter the mine, work in it, know it, and rub elbows with men who have done things in the field before he is able to face the problems offered by a new development or project.—Raymond Francis Yates in Scientific American.

Elements That Must Be Considered in Cost Estimating[*]

The subject "Cost Estimating" is of unusually wide scope as practically each type of contract work has to be analyzed on its own merits and is subject to special considerations. Inall cases, however, the following elements enter and must be given consideration:

Financial Credit
Constructive Skill
Use of Plant
Hazard
Profit.

Financial Credit.—The contractor should make a carefully prepared schedule of the amount of money which will have to be invested in the proposed work from the time he signs the contract until his final estimate is rendered, and from such schedule he must determine the amount of interest this money will cost and this amount is a proper charge against the work. If this is not done the contractor is merely contributing to the owner this amount.

Furthermore, a careful analysis along these lines will often disclose the fact that a certain piece of work requires a larger amount of money to handle it than is apparent at first glance, and such a condition might work a hardship if not disaster on the contractor in spite of the fact that all other considerations had been taken care of. It is a notorious fact that on certain types of contracts, pay for preliminary work, which may be a large item, cannot be secured through the medium of the regular unit prices until the work has progressed well along to completion.

Constructive Skill.—Contractors engaged in business are entitled to receive compensation in the shape of an annual salary for personal services rendered and it is our belief that any computations of cost should include sufficient amount to cover such salary whether it be that of a single individual or various members of a partnership or corporation. If this is not done the contractor is contributing his services to the owner without remuneration, because by no stretch of the imagination can there be any rightly considered profit except as over and above a reasonable salary allowance to the contractor himself.

Use of Plant.—This item justifies an independent discussion by itself and we suggest that the association appoint a committee to deal directly with it.

Hazard.—Many specifications include clauses which contemplate making the contractor assume risks which should properly be borne by the site, or in other words, should be at the owners' risk. In making a proposal on such work the contractor has two alternatives—one to protect himself in his proposal against such risks by special provision in his proposal, or secondly, to put a large value on any possible risk which he is asked to stand.

It may be well to add in this connection that while it ordinarily behooves a contractor to be somewhat of an optimist he can well afford to be a confirmed pessimist when figuring this portion of a contract. It is possible this fact more than any other has caused good firms to have to go out of the contracting business.

Profit.—As to the necessity of a profit we can all be agreed. As to the amount which must be added as a percentage on the cost, differences of opinion will exist, but it must be remembered that the contracting business is a particularly hazardous one; that it is irregular in volume and that every contract will not necessarily be profitable.

Furthermore, it must be remembered that the average merchant sells goods from his shelves at a profit with a definitely established cost for the goods themselves. The manufacturer sells on short term contracts—his overhead, plant installation and plant maintenance costs are established and regular, and while he may not in all cases be willing to admit it, the manufacturer is practically working on a cost plus basis today. The only difference in most cases between his method of fixing prices and that of a cost plus construction contract is that the manufacturer can and does add a larger profit for the use of his organization, brains and energy. The contractor must provide his plant, must guess at the cost of it, in place, must guess at the operating cost, must guess successfully if he is to stay in the business as to what the labor market will be, and if he is willing to do this he is surely entitled to a fair margin of profit.

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[*] From the May Bulletin of the Associated General Contractors of America. Report of Committee on Cost Estimating of the Northwestern Association of General Contractors. The committee included N. F. Helmers, chairman; J. C. Baxter and F. J. Herlihy.

Necessary Factors in Estimating.—The following items also enter into most work and must be considered in detail before the preliminary cost of a piece of work can be considered as complete:

Interest.
Overhead expense.
Bonds.
Insurance—
  Employers' liability.
  Public liability.
  Fire insurance.
  Special risks.
Freight on outfit to and from work.
Moving in and out.
Land damages.
Camp and other buildings.
Preliminary work.
Cost of materials plus freight.
Hauling materials.
Supervision.
Labor.
Loss on board.
Transportation of labor.
Tools.
Plant rental.
Supplies.
Running repairs.
General repairs.
Special.
Machinery.
Fuel and power.
Water.

Taking up these items in order we will comment briefly on each:

Interest.—This is covered in our discussion of financial credits.

Overhead.—A contractor should establish the proper cost of the overhead charges in his business. This should include the charges, salary allowance for members of the firm, traveling expenses, etc. Provision should also be made here for the maintenance of an equipment storage yard.

Bonds.—no comment should be necessary here on this item.

Insurance.—It is not necessary to make a discussion of the ordinary items, but we wish to call attention to the fact that prudence would require that any combustible material, together with camps, storehouses, etc., should be insured and such insurance is of course a proper item of cost to the work. There are often special risks which occur upon a job which may be protected by insurance, and such insurance is also part of the cost.

Freight on Outfit.—This is possibly a portion of the item following, but we have listed it separately because we believe that many contractors under-estimate the amount of freight that they will be required to pay on their outfits in such cases.

Moving In and Out Expense.—This is an item frequently overlooked by contractors, but one which requires careful consideration. First, there is expense of loading outfit in the contractors' yard; second, the unloading of it at point of destination; third, the moving of it perhaps many miles across country; fourth, the setting up and getting plant ready to operate, and the reverse of all these operations until the plant is again delivered in the contractors' yard.

Land Damages. This is an item which we believe many contractors neglect entirely and still it is one which costs considerable sums of money. This seems particularly true in connection with county road work.

Land damages accrue from the use of property for camping purposes, from moving outfits across fields for the diversion of public highways, and for storage yard and other construction layout.

Camp and Other Buildings.—This is another fruitful source of under-estimating by contractors, often in the loose assumption that "The boarding house will pay for the camps." If such a condition ever existed it must have been a great many years ago and we believe that present-day conditions necessitate including the cost of all camps and temporary buildings required to carry on the work. We further believe that contractors should be careful to avoid the thought of high salvage values to avoid subsequent disappointment.

Preliminary Work. This is an item which should not only be considered in cost estimating but we believe that we should digress from the subject for a moment and call attention to the fact that it is probably a duty which every contractor owes to himself to work out a definite scheme of handling a piece of work before he proceeds with an estimate. This does not mean that he must detail the laying out of an entire piece of work but that he must see clearly that a certain general line of procedure can be followed with expectation of proper results therefrom.

Cost of materials.—Mention is made of this particularly to emphasize the fact that a cost estimate is usually based on certain material quotations, and it is very necessary in these times that a prospective bidder should be careful to be properly covered with material quotations when making a bid and to close up promptly with the material dealers after the award of the contract.

In connection with this comes a question of freight which must not be overlooked, but in case of the present railway situation it would seem necessary for every bidder to make special provision in his proposal to protect against a change in freight rates during the time of the work.

Hauling Materials.—All hauling costs should be very carefully analyzed, as they are often a fruitful source of under-estimation.

Supervision.—Care should be taken to see that any computation of labor also includes any supervision which is not covered in the item of overhead. This would usually mean general foremen, timekeepers, labor agents.

Labor.—Labor is perhaps the most difficult item in the computing of cost which a contractor has to deal with. Rates have been rising for several years and it is apparent that wages have not reached their peak. Provision must be made somewhere to protect against what the bidder considers the maximum rate which will accrue during the life of the contract.

Loss on Board.—In most cases there is a definite board loss in connection with camps. While this may not be true with large camps, working through a considerable period of time, the small movable camp such as is in vogue on highway work usually contributes a constant loss to the work.

Transportation of Labor.—This is an item very often neglected, yet it is very common to have to advance railroad fares to laborers with the resulting increase in the cost of the work.

Tools. Contractors often fail to make the proper allowance for tools. Careful analysis of work done will show that a tool item is a very appreciable one in every contract and will also indicate that tools do not carry any too well from job to job, but that there is a definite and heavy loss on every job in connection with this item.

Plant Rental.—As mentioned before this should be covered by special paper.

Supplies.—This is an item which is often neglected as being a minor consideration. On certain classes of work it is really, instead, a very heavy item. The cost of packing, grease, hose, rubber boots and other rubber goods, should be given careful consideration and the contractor will save himself money by checking up his past work and arriving at a clear understanding of what such costs really are.

Running and General Repairs.—These should be discussed in connection with the use of plant, of plant rental, but in any case the contractor must understand that they are necessary parts of the cost of doing a piece of work.

Special Machinery.—On many contracts it is necessary to employ in addition to an ordinary contractor's plant some special form of machinery either purchased from a manufacturer or built by the contractor for the work. In either case plant rental is not a proper charge for this class of equipment. The entire cost of it less its scrap value must be charged to the one job on which it is used, otherwise a contractor may complete a large amount of work and find the entire profits tied up in machinery which has little value other than scrap.

Fuel and Power.—The cost of power especially varies so much in different localities that the bidder should acquaint himself carefully with the local conditions. If a large amount of fuel is involved careful allowance must be made for the hauling an dhandling of same.

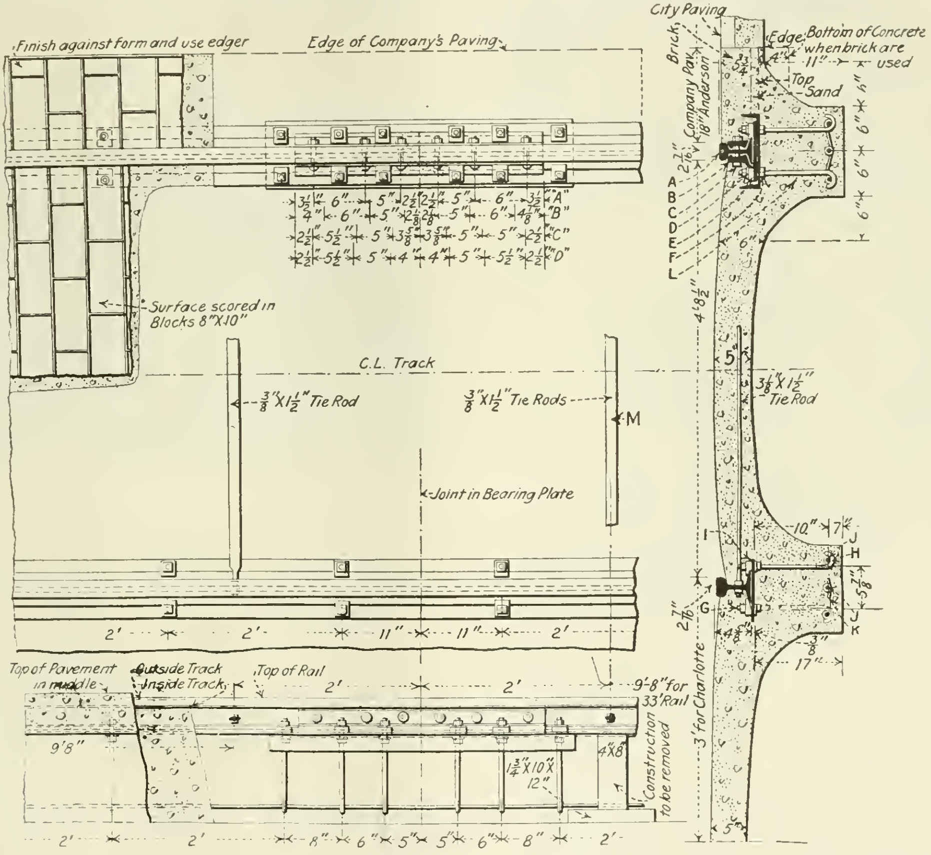
Water.—This item often becomes a serious obstacle to the proper handling of work and is one that requires a great deal of attention. It sometimes adds very materially to the cost. In addition to this we wish to impress all contractors with the desirability of investigating the available water supply in connection with a given piece of work before making their figures.

Cost Keeping.—We cannot close the discussion of cost estimating without dwelling for a moment on the question of cost keeping. The fact that so many contracting concerns are closed out of business each year is a strong indication that something is not correct with the way construction work is figured. A good deal of it comes from neglecting a number of items which we have mentioned above and which do not appeal to some men as being of enough moment to give direct consideration to when making figures. Other trouble comes from not keeping careful cost data of work done and analyzing such costs.

It is not the purpose of this paper to go into detail regarding such things, but we believe that a contractor should avoid using manufacturers' statements of operating costs as well as any other stop-watch methods, as they usually spell loss if not disaster. A certain amount of work done per day with a crew operating at a certain expense per day never means that the division of that daily cost by that daily output is the unit cost of the item in question. There are delays and other things which so affect this price that it may be over one hundred per cent out from the actual cost when all things are taken into consideration.

Tieless Concrete Beam Track for Street Railway

A unique form of track construction has been made standard by the Southern Public Utilities Company, operating street railway systems in Charlotte and Winston-Salem, N. C., and Greenville and Anderson, S. C. The construction was originated by Mr. E. F. Taylor, formerly general manager of the company, and consists of a rigid type of track construction with the rails set in concrete and anchored by means of long hook bolts, without the use of any cross ties. We reproduce herewith the drawing of this construction taken from the Electric Railway Journal.



Construction Details of Tieless Concrete Beam Track.

A—A.S.C.E. 70-lb. rail, 33 ft. long.
B—A.S.C.E. splice bars punched as shown and notched as shown for clips 1 16 in. clear.
C—Bolt, standard ⅞-in. track.
D—High-tension 3 16-in. washer for ⅝-in. bolt.
E—Carnegie rail clip No. 103.
F—Hardwood or fiber washer.
G—⅝-in. x 3-in. standard bolt.
H—⅝-in. anchor bolt.
I—⅜-in. x 8-in. continuous plate.
J—½-in. corrugated bars, continuous (20 ft.).
K—Wire support.
L—10-in., 15-lb. C under joints.
M—⅜-in. x 1½-in. track tie rod.

The top 2-in. surfacing of the concrete is in the proportion of one part sand to one part aggregate, while the remainder is a 1:2:4 mixture. The concrete is allowed to cure for twenty-eight days whenever practicable, as it has been found to wear better when given plenty of time to harden.

The company has approximately 12 miles of this type of construction in use, of which about 4 miles has been in service four years and the remainder for various shorter periods. The cars which have been operating over this track vary in weight from the light 13,000-lb. safety car to the heavier four-motor, double-track 29,000-lb. cars.

Influence of Tractors on Use of Farm Horses.—The number of horses displaced by tractors in the corn belt is largely determined by the number it is necessary to keep for corn cultivation, and other work current at the same time which the tractor can not do. This is one of the facts brought out by an investigation recently made by the U. S. Department of Agriculture in seven corn-belt states, relative to the influence of tractors on the use of horses, the results of which have been published in Farmers' Bulletin 1093. The department has drawn on the experience of 191 tractor owners, in the preparation of this bulletin. It was found that the number of horses disposed of by the farmers in question after buying tractors was between two and three a farm. The average number of acres tillable by horses was increased 12, and the average size of the farms by a total of 22 acres. Several operators displaced horses entirely on plowing, disking, and harrowing. Few operators allowed their horses to stand idle while the tractor was in use. A 3-plow tractor on these farms does the work of 8½ horses in plowing, disking, harrowing, and harvesting.

Cross-Tie Production on the Pacific Coast

The following facts and figures are taken from a paper by Mr. E. M. Blake, production engineer, of San Francisco, which was presented at the recent convention of Railroad Tie Producers in Chicago:

A fundamental difference between the production on the Pacific Coast and tie production in the rest of the United States, is that on the Pacific Coast tie production has been largely incidental to the lumber industry, while elsewhere many companies have been organized with the sole object of producing ties.

It is estimated that there are in the United States today about 550,000,000 acres of standing timber, and of this amount about 80,000,000 acres are in the Pacific Coast states. Although a relatively small percentage of the whole, it is estimated there are about thirteen hundred billion board feet of standing timber on these 80,000,000 acres, which is approximately one-half of the remaining supply of standing timber in the United States. About one-half of this quantity, or 630 billion board feet, is estimated to be Douglas fir, representing about one-quarter of the total timber stand in the United States today. Of the total of thirteen hundred billion board feet, about 340 billion are found in the State of California, about 510 billion in the State of Oregon, and about 450 billion in the State of Washington. It is interesting to note, in comparison, that the total stand of yellow pine in the southern states today, based upon figures recently compiled, is probably not much in excess of 225 billion board feet.

The following figures give an approximate idea of the relative stands in 1920 of the various kinds of timber in the Pacific Coast states:

Timber.	Location.	Billions of board feet.
Douglas fir	California	65
	Oregon and Washington	565
Redwood	California	75
White pine	California and Southern Oregon	120
Sugar pine	California and Southern Oregon	35
White fir	California and Southern Oregon	40
Cedar	California and Southern Oregon	10
Other species	California and Southern Oregon	10
Spruce	Oregon and Washington	50
Cedar	Oregon and Washington	60
Hemlock	Oregon and Washington	85
Western yellow pine	Oregon and Washington	125
Western larch	Oregon and Washington	20
Other species	Oregon and Washington	40
Total stand, estimated		1,300

In connection with the use of Douglas fir it is interesting to note that the great durability and resistance to saturation by water of Douglas fir and its great mechanical strength combined with its lightness in weight particularly fit it for use in the form of cross ties. The unusual refractoriness of its cellular structure has, in the past, tended to limit the treatment of the heartwood with creosote oil or other preservatives, but the recent development and perfection of the mechanical perforating process assures a greatly increased use of treated Douglas fir in cross ties in the future. Douglas fir also grows very large in size and very dense in stand and the number of hewed ties is very small, most fir ties being sawed from the logs. The stands commonly run over 1,000,000 board feet to the acre. Individual trees run up to 14 ft. and 15 ft. in diameter and over 300 ft. in height. They often grow to a height of 150 ft. without a single branch. Structural timbers 18 by 18 running from 120 ft. to 140 ft. in length and timbers as large as 36 by 36 and even 46 by 46 running from 50 ft. to 80 ft. in length are readily available. On account of its large average size, therefore, it is probable that the majority of Douglas fir cross ties will generally be manufactured from the heartwood of the timber.

It is quite possible that tie production on the Pacific Coast may become in the future a distinct and separate business of itself, as it is east of the Rocky Mountains, correlated with but independent of the lumber mill and in the wake of the larger lumber logging operations, the great forest areas of the Pacific Northwest may offer employment to thousands of laborers in the splitting and hewing of cross ties from the smaller growth and in the lesser logging operations connected with portable or small permanent tie sawmills. Whatever form the production of cross ties on the Pacific Coast may take in years to come, it is undoubtedly the destiny of Douglas fir to fill the most important part, representing as it does about one-quarter of the total stand of timber in the United States today. Mechanically perforated promptly after its manufacture to control or prevent checking, to hasten air seasoning, and to insure a uniform pre-determined penetration of preservative, then economically treated with the maximum conservation of oil possible and with the vitally important reduction of time and temperature made possible by perforating, it is doubtful whether any cross tie timber will give a better account of itself in the track bed than Douglas fir.

Although reforestation has so far been carried out in the Pacific Northwest on only a small scale, it is the opinion of expert timber engineers, recently expressed, that Douglas fir is growing at a rate equal to that at which it is being cut today and that, at the present normal rate of growth, the present supply of standing Douglas fir timber will be entirely reproduced in about 100 years. It is the opinion of these engineers that there is enough timber in the Pacific Northwest today to maintain the entire country's supply for about 100 years.

Chemical Eradication of Weeds

The Department of Agriculture of the University of California has recently issued a bulletin giving in detail a method of killing weeds by means of an arsenic solution which acts as a sterilizing agent in the soil. While the cost of treating a railway roadbed in this manner would undoubtedly be considered too expensive, nevertheless its use in certain localities might be worth while, such as long fence rows, roadways, etc., in the vicinity of station grounds.

The cost of materials for the treatment is given as $2 per 100 sq. yd. At this rate it would amount to about $95 per mile of railroad track for a strip 8 ft. wide.

The following is quoted from the above mentioned bulletin:

The following formula for the preparation of a stock solution is preferred on account of its simplicity:

Granulated caustic soda (98 per cent)	10 lb.
White arsenic (arsenic trioxide, 99 per cent)	20 lb.
Water, to make	5 gal.

The solution may be made as follows: Dissolve the caustic soda in about 2 gal. of water in a metal or wooden vessel (preferably iron) and while still hot, add the dry arsenic, about 1 lb. at a time, at a sufficient rate so that the solution is just at the point of boiling, but does not actually boil. Stir continuously during the addition of the arsenic and until all is dissolved. Considerable heat is produced by dissolving the caustic soda. Additional heat is furnished by the chemical reaction involved in the union of the caustic soda with the arsenic to form sodium arsenite. After all the arsenic is dissolved, let the solution cool and add water to make exactly 5 gal.

Do not add cold water to the hot solution. An explosion may result, as the solution is hotter than the boiling point of water.

If, for any reason, the arsenic fails to dissolve without the use of heat, a solution can be made by warming the mixture, unless the materials are of low grade. If hard water is used there will be some insoluble matter in suspension; but it may be disregarded unless present in large amount.

The above makes a convenient stock solution for diluting to any desired strength; that is, each gallon contains 4 lb. of arsenic trioxide; a quart, 1 lb.; each fluid ounce contains ½ ounce of arsenic trioxide.

For each square yard to be treated take 2 fluid ounces of the stock solution described and mix with 1 gal. of water; or for every 100 sq. yd. take 1½ gal. of the stock solution and mix with 100 gal. of water. The solution may be applied to smaller areas by means of an ordinary garden watering pot, using 1 gal. of the solution to each square yard. A barrel or tank may be mounted on a sled and connected to a sprinkling device for treatment of larger areas. The rate of delivery will have to be regulated by experiment, but it is important that each square yard shall receive an amount of the solution containing at least the equivalent of 1 ounce of arsenic trioxide.

If the soil is thickly covered with either living or dead weeds it will be well to remove them as completely as possible before the poison is applied. The weeds will not materially assist in carrying the poison to the soil and the amount adhering to them will be wasted.

If this powerful agent of destruction is to be employed as a tool for the control of weeds, the user must be alert to the fact that it is a destroyer of both animal and plant life, the harmful and beneficial alike. Ample precautions should be taken to prevent live stock from eating the poisoned grass which may remain on the soil.

Methods of Placing Concrete Under Water

In the early subaqueous concrete work, the concrete was deposited directly under the water by means of a box with a movable bottom, or it was placed in bags. Of late years three other methods have been used: The tensile or spout system, the ram system and the gravity flow system: The last two were employed on work on the Lachine canal. The tremie system has been used on the Detroit tunnel and other work in America. An interesting discussion of these methods of placing concrete under water was given by Mr. Henry R. Lordly, in the March Cornell Civil Engineer, from which we quote as follows:

Constructing Walls for Lachine Canal by Ram System.—The ram system is the name given to first method used in the relining work on the Lachine canal, carried out under the supervision of the writer, but it was only used on thin walls, or where the narrow space between the back wall and the face mold or form might cause the concrete to get jammed and thus prevent its flowing down. In wider spaces the gravity flow system was adopted and the ram discarded.

The slope walls of the Lachine canal, near Montreal, Canada, had to be rebuilt, or faced, without interfering with navigation. A system of large wooden molds, 100 ft. by 22 ft., and secured at from 1½ to 2 ft. from the slope walls, was adopted. The mixing plant, which was operated on scows, was provided with a movable oblique arm, at the end of which was built an iron box, with movable top and bottom. This arm, called the ram, carried the concrete down and when at the required depth the bottom of the box was opened by a steel cable and the concrete deposited. At times the ram was not operated but kept near the top and used as a chute, the concrete being deposited in such a manner that it took a natural slope and pushed itself forward; this method will be described later. Fig. 1 shows the ram system in operation. The oblique arm is the ram, and the box, which was only 18 in. wide and held 1 cu. yd., is directly under the chute from the mixer. The top of the mold may be seen just above water.

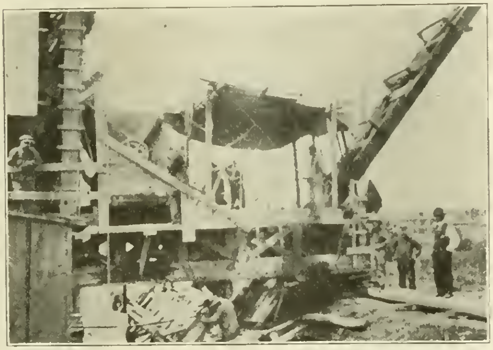


Fig. 1—Ram System of Placing Underwater Concrete.

Gravity Flow Method of Constructing Bridge Foundations.—On one occasion, while supervising the placing of a concrete foundation for a bridge, the site was drowned out by a spring freshet until there was a depth of 23 ft. of water to contend with. To stop the work was out of the question and, as all the forms were in position, it was decided to begin placing the concrete at one end, bringing the mass above the water in one corner. This was done by the aid of a chute; later the chute was discarded, and the concrete dumped on the edge of the mass, the added weight helping to push the concrete forward until it approached its natural angle of repose. The amount of material placed in this manner had a length of about 80 ft., and a width of from 8 to 14 ft.; upon the removal of the forms the flow lines showing the angle at which the mass moved forward were readily seen. This method was afterwards carried out in portions of the work previously described and, in particular, on various pieces of vertical walls, in a current of water, and notably the Lachine dam which up to the present, is probably one of the most extensive pieces of under-water concrete work in America; i. e., if we except the 5 miles of walls in the canal proper.

Method of Operating with Gravity Flow System.—Figure 2 is an illustration of the gravity flow method. The concrete is confined both back and front by molds, or by a mold and a previously built wall or embankment, and at the starting end by a bulkhead.

Work is started in one corner, the position of the mixer being indicated by the letter A in the diagram. The various deposits of concrete take a decided shape as indicated by the numerals 1, 2, 3, 4. After the point 4 is reached the concrete is dumped on the top and pushed forward, with little effort, by men with light wooden scrapers or a tool in the form of a rake. It then flows down to take the position indicated by 5A, which represents the last material placed by the mixer at A, before it is moved forward to its second position at B,—and so on. The writer has used this system to build a wall 9 ft. wide at the bottom, 4 ft. at the top and 18 ft. deep, the structure being in water 17 ft. deep and having a flow of 6 or 7 miles per hour. There is nothing difficult about it, everything depending on the quality of the concrete, and on careful supervision.

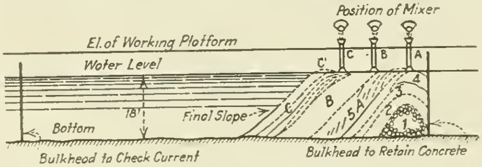


Fig. 2—Gravity Flow Method, Showing Slope of Flow While Concrete Moves Forward.

The chief advantage of this method lies in the fact that the concrete flows forward in one direction with its narrowest face for the wash surface; this face is the oblique cross-section shown by the plane of the angle of repose.

Concrete Placing Methods for Underwater Reconstruction of Lachine Dam.—Figure 3 is a sketch of the method of carrying out the underwater reconstruction of the Lachine dam, in which the "gravity flow method" was employed, under the supervision of the writer. This dam is at the entrance to the Lachine Canal and has a total length of about 3/5 mile, ½ mile being reconstructed. It divides the ordinary shore current of the St. Lawrence River from the rapid flow in the middle of the river just as it begins to descend the drop of 45 ft. which takes place in about 9 miles, the length of the canal. The original dam was built of cribwork and filled with heavy stone, but the repeated action of the ice flows, and natural wear, made it quite unstable. With a head of about 1 ft. there was a flow of water through the dam, portions of which were undermined. The main difficulty was to

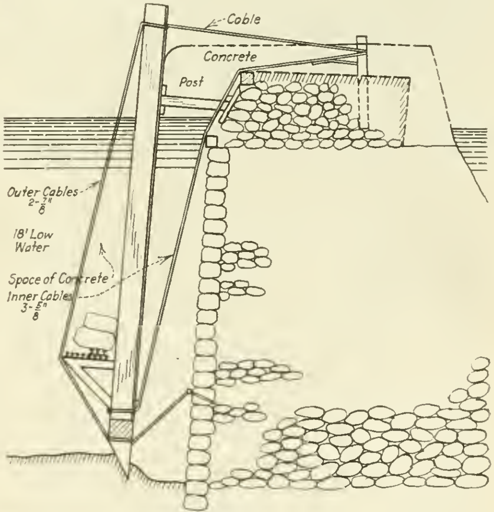


Fig. 3—Method of Holding Mold for Subaqueous Concrete Facing.

secure the big 100 ft. molds in place, and to stop this flow; it was also necessary to control the current formed by the inward flow of the water towards the mouth of the canal.

The sketch (Fig. 3) shows a big mold in place and being held in position by the inner and outer steel cables, with posts as struts; this method had also been used during the construction of some of the 5 miles of walls previously built in the canal. Two ⅞ in. cables were used on the outside and three ⅝ in. cables on the inside. The outer cable was secured to a short piece of cable, about 8 ft. long, previously placed by the diver, and secured to the timber crib-work. This short cable had an eye at its end to which was attached the main cable. The inner cable was secured to the mold in such a manner that it could be disconnected at the end, or cut by the diver, after the work had been done. The length of cable was left in the wall. The mold was held down by its own weight, plus the dead weight of rails and stone blocks, placed on the platform which is seen above the diver's head.

Before the molds were placed a dredge cleaned out the site and the foundation was further dredged out, partially by machine and finally by the divers. Upstream and downstream bulkheads were used as illustrated in Fig. 2 and after these preparations were made the work of depositing the concrete was begun. In several places there was difficulty in stopping the flow of water through the timbers of the dam, and to accomplish this a special method had to be employed. This consisted of using sheets of 11 oz. canvas 24 ft. wide, sewed up in lengths of about 60 ft. These were placed against the face of the old dam and secured at the top and bottom, battens being nailed over the vertical joints; in this manner the water was made quite still and when the concrete was being placed no cement was washed through, as was evidenced by the clear water on the outside of the dam opposite the site of operations. No difficulty was experienced in holding the molds and no slides occurred. As a rule these dangers lie in bringing the concrete too high on the first day's work. It is well to fill only part way and permit this to get set, at least over night, before continuing the work.

When once a sufficient length is finished, such as section A in Fig. 2, and this sets hard, the concreting can go on continuously and will flow forward without any troubble. The mixing and supply plant used here was all on scows; one scow for mixer, bins, and machinery; one scow for sand; one for stone; and a special covered scow, or barge, for the cement. The diver's outfit was on a small scow containing house and pumping outfit.

Cost of Subaqueous Concrete Work.—The cost of this work, and the vertical walls, built on the subaqueous system, was not as great as some similar sized walls constructed in the dry, under the supervision of the writer. The contract price of the concrete, per cubic yard, was about the same in each case, but the total cost of the dry walls exceeded the underwater work by the additional expense caused by driving piles; for pumping and in erecting; and for removing the molds by high priced carpenter labor.

In some classes of work it is absolutely necessary to build a cofferdam and to dry the site, but in many cases, in still water, the system above described is all that is necessary. Cheap, strong, and interchangeable molds, securely held, and floated into place will cost less to handle than molds erected and taken down in small sections in the dry.

Today there are other forms of molds available than those used above. Steel sheeting can be used up to at least 60 ft. lengths and redrawn on completion of the work; and there are various types of concrete shells, caissons, or boxes, that can be premolded, sunk on the site, and filled with the required content.

Points to Be Noted in Carrying Out Subaqueous Concrete Work.—In carrying out underwater concrete successfully the points to be noted are:

The stiffness and rigidity of the forms and the bracing of same; cracks in the molds will cause wash lines.

If working in a current begin at the downstream end and block the upper end by a bulkhead to prevent any wash of the water as it flows down.

Do not commence operations too soon in the year when the water is ice cold, or to continue too late in the fall, for the same reason.

Don't remove the molds too early; although in favorable conditions and with good concrete, five days is often not too soon. Take longer time if vessels are apt to bump against the work shortly after completion.

Materials. All the materials should be the best of their kind. Don't use any material simply because it can be obtained handy. A good quick setting cement should be selected, but only after it has stood satisfactory setting tests in the coldest temperature at which it is going to be used.

The sand should be clean, sharp, and silicious, and should contain graded particles ranging from those retained on a No. 80 sieve down to those retained on the No. 10 sieve, which is usually the coarsest. Some good sands have a small percentage retained on the No. 100 sieve with some on the No. 6 and make ideal concrete.

The stone should be clean and of good quality as to hardness, and what is generally known as the 2-in. size commercially is acceptable. A small percentage of pieces longer than 2 in. which often work through the crusher will not be objectionable. Shaly limestones that disintegrate after being taken from their natural beds should not be used.

The stone used for the underwater concrete on the Lachine canal was a silica sandstone. It is a very hard stone with an irregular break and is rather severe on the crusher. Cement adheres to it well and for concrete work it cannot be beaten. Water worn gravel should not be used.

Testing and mixing. One bag of cement out of every 10 bags should be tested for setting, in addition to the standard tests under which it is purchased. These setting tests should be made at the temperature of the water in which the concrete is to be placed.

Mortar tests, setting in the proportions of cement and sand to be used in the work, should also be made under the above conditions.

A mechanical mixer is necessary on all work of this kind as a constant flow of concrete should be kept up. The concrete should first be emptied into a receiver placed below the mixer from which it can be allowed to flow, as required—the flow being regulated by an automatic gate. A drum mixer is preferable and each batch of concrete should be turned for at least two minutes at the regular speed of the drum before it is deposited into the receiver. From 180 to 200 cu. yd. in 10 hours may be considered a maximum day's work.

Unless the molds are secured very solidly and their stability is beyond doubt, the depth of any one layer of concrete should not be over 10 or 15 ft., although it is always best to come up to water level.

Continuous mixers with automatic measuring devices have no place on an underwater concrete job. Every batch must be up to the standard and be able to stand the inspection of an experienced man who can readily detect an off-mix by its color and consistency.

The proportions of cement, sand, and ballast, should not be decided upon until all of the materials have been inspected and tested. With the present day standard American cements, the proper proportions will be within the limits of a 1 to 2 or 2½, of cement and sand, to 5 parts of stone. Some crushed stone, such as the irregular crushed sandstone when run into the measuring box from an overhead bin, bulks up considerably more than an evenly crushed limestone and this point should be remembered when measuring to get cubic yard results.

The mix should be what is called a putty mix and care must be taken to get the required amount of water; this must be largely a question of observation. Automatic supply tanks for water are not reliable unless adjusted to suit hot or cold weather conditions and must be under constant supervision.

One man should be placed in charge of the cement supply. He will get the bags ready to empty and take care of the bags afterwards and tie them into bundles to be returned to the mill. The tally on the empty bags gives a check on the cubic yards mixed during the day.

Inspection. The inspector is an all important man on any concrete job but particularly so on an under-water one. A man who has had cement-laboratory experience combined with practical mixing of concrete is the most valuable. He should be well paid and kept up to a high state of efficiency by the constant supervision and advice of his superior.

A second inspector should be available so that changes can be repeatedly made, as one man is apt to grow stale by too long periods of duty.

Diving staff. On most underwater work it is necessary to have a good diver with capable assistants and an efficient diving outfit. He must aid in getting the lower part of the site cleared and must adjust all cables, supports, braces, and loads on the molds. On a very extensive job it is well to have one of the young engineers able to put on a diving suit and go down to examine the work. This has a good influence on everybody connected with the job and helps to maintain efficiency.

The writer has learned by long and continued experience that when, on a job of underwater concrete, or any other class of concrete, a man in a responsible position becomes careless by reason of being too long on one class of work or by imagining that he knows it all, he is dangerous; the proper thing to do is either to change his work or to dismiss him instantly as an example to others.

Subaqueous or underwater concrete is as easy and as sure as any work done in the dry, but it requires, as in all engineering work, care, more care, and still more care. Without that, it will fail!

How to Turn a Caterpiller Shovel or Dragline in its Own Length

It is no trick at all to turn a caterpillar mounted revolving shovel or small dragline in less than its own length. The following method of doing this is given in The Excavating Engineer.

Unless on hard ground, throw plank under the off caterpillar. Take a block, preferably about 14 in. high and set it against the treads of the caterpillar on the rear corner. That is, if you were intending to turn to the left, set it diagonally against the left forward corner of the left caterpillar, which is not driving. The block should be at least 14 in. high, as stated, in order to set against a tread above the center of the tumbler.

As she turns, keep throwing plank under the off caterpillar. On good ground you can kick around as fast as you can throw planking, and on hard ground no planking is required, but where the bottom is soft or muddy, the material will pile up against the off side of the off caterpillar. One way to get around this is to drive ahead with both caterpillars far enough to clear and repeat the operation.

There is one precaution to be observed here. When turning the caterpillar on soft ground as above described, heavy stresses will come on the brackets and tumblers of the caterpillars because the links are plowing sideways through the ground. These stresses are likely to result in excessive twisting strains from the side reactions.

Consequently, it is preferable when turning on soft or muddy ground to turn as an automobile is turned in a cramped place, by a series of zig zag movements. In other words, by turning on an arc of, say, 15° for a short distance. Then moving straight forward or backwards and repeating the operation.

Effects of Acid on Wire Rope

It has been conclusively demonstrated, states Leschen's Hercules, that acid of all kinds has a decided corrosive and therefore detrimental effect upon wire rope. This applies to both before and after a rope has been put into service.

Wire rope should not be stored in the same building with acids, and when a rope is stored it should be covered to protect it from uric and other acids. If wire rope is to be stored for any length of time, the outside layers should also be thoroughly coated with a good lubricant.

Where it is necessary for a wire rope to work in the presence of acid or acid fumes, as in some mines, etc., a thorough and regular application of a protective lubricant is essential.

There are occasions when it is desirable to determine whether mine water has become impregnated with acid or has an alkaline tendency.

Such conditions can be readily and quickly discovered with litmus paper.

The method is as follows:

If upon immersing a blue sheet of litmus the paper turns red, it is a direct indication of a free acid tendency.

If upon immersing a red sheet of litmus the paper turns blue, it is a direct indication of an alkaline tendency.

If neither color of litmus paper changes during immersion, it denotes a neutral condition of the water, free from acid or alkaline tendencies.

Frequently acid or alkali is combined with other elements, in which case a chemical analysis is necessary to detect its presence.

Fair Contracts and Their Legal Aspects*

By JAMES B. KERR,

Attorney at Law, Portland, Ore.

For many years I was associated with the legal department of the Northern Pacific Ry. and in later years I have represented in one or two cases the down-trodden and oppressed contractor. The contractor ordinarily does not make a very good client. He is not a litigious sort of a soul. He usually picks the party with whom he deals, and if he does not get a fair, square deal, why he usually pockets his loss and goes about his business, resolving never to bid on any job of that kind again. That is peculiarly true in contracting with railroads. My experience has been that the price which a railroad has to pay for excavation depends largely upon the personnel of its engineering staff. If the chief engineer and his assistants down the line are competent, honest and fair, that has about as much to do with the bid which is interposed as the cost of labor or the length of haul. In other words, in most contracts of that kind the personal equation is the controlling feature.

The Engineer as Arbiter.—There is no necessity, to my way of thinking, for a long or complicated document to fix the rights of the parties with respect to the place of highway work, for example. I think a contract need contain nothing more than this: first, the names of the parties; second, a description of the work; third, reference to plans and specifications; fourth, terms of payment; and fifth, a statement of the authority of the engineer.

The practice of inserting on contracts provisions conferring on the engineer the authority to act as umpire is in a sense an outgrowth of the ancient practice of submission of matters of difference to arbitration and award. The adoption of such a practice arises from considerations of necessity. It is a curious thing, however, that in many railroad contracts, and in many standard forms of public construction contracts, instead of confining the authority of the engineer to those matters with respect to which it is proper to commit authority, the contracts make the strange error of enlarging the powers of an engineer beyond the extent to which the law permits the parties to go.

Of course there are certain things involving matters of technical knowledge and technical skill, which, because of that fact, and also from considerations of convenience and necessity, must in the nature of the case be committed to an engineer. For example, if a contract has to do with excavation of material and unit prices are fixed for the different kinds of material, it is impracticable to leave to the courts, in the first instance, in the event of a dispute, the determination of what is solid rock and what is cement gravel, and what is hard pan and what is earth. The courts know nothing about matters of classification. It is a matter of experience; it is a matter of pure technical knowledge. And in the second place, as a matter of necessity and the overwhelming demands of convenience, there must be some arbiter on the ground who shall decide those questions.

Contract Provisions That Are Against Public Policy.—There are other questions which the law says that it is against public policy to commit to an engineer, although contracts very often carry such provisions. For example, you have signed contracts without knowledge of their contents and later, upon examination, have found that they contained provisions that in case of a dispute to the meaning of any term or phrase in the contract the decision of the engineer shall be final. Now the courts say that this is against public policy, because the parties cannot by agreement oust the courts of jurisdiction to interpret the meaning of contracts. But as a practical matter such a provision is not a matter of serious concern, provided you have a competent and an honest and an intelligent engineer; and provided, too, that the contract itself is well drawn except in this respect, because ordinarily disputes as to the meaning of the contract do not arise. But at the same time such a provision in a contract may result disastrously if the contract finds its way into the hands of an engineer who is inclined to assume undue authority and who has an inclination to be arbitrary. Read literally, such a contract purports to confer absolute and unlimited authority on the engineer in charge and occasionally there is a temptation to abuse the power actually granted and to exercise powers which are not conferred.

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*From an address given March 2 before the First Annual Convention of the Associated General Contractors of the Pacific Northwest.

Decision of Court on Extra Work.—There is another provision which is often inserted in contracts, and that is that the engineer may require the contractor to do such extra work as he may direct, and at such price as the engineer shall prescribe, and, furthermore, that the engineer shall have authority to make and cause such alterations to be made in the work as the engineer shall determine to be desirable and that the contractor shall do the work at such price as the engineer shall fix. Now those provisions are not uncommon, and you gentlemen, without reading them, have signed contracts containing such provisions. But the courts uniformly hold—the Supreme Court of Oregon holds—that the extra work is only the slight amount of extra work which can be reasonably anticipated to carry out the main purposes of the contract; that the alterations are only those changes which are incidental to the carrying out of the main contract. This is a matter of such vital importance to you and to all those having this subject in hand that I brought here a quotation from a decision of the United States Circuit Court of Appeals on this question in the case of Salt Lake City v. Smith, reported in 104 Federal, where a change was made from a small steel bridge over a stream to a large stone viaduct, ordered by the engineer in pursuance of one of these clauses in the contract. The court said:

> The stipulation that the contractor shall do such work in connection with that described in the agreement as the city engineer and the Board of Public Works may direct is as effectually limited by this fact to such extra work of proportionally small amounts as was necessary to the construction of the contemplated conduit as it would have been if this restriction had been written in the agreement in so many words.
>
> This was the theory upon which the case was tried, and it was the true theory. It is just to the city, fair to the contractors, and it accords with reason and established law. The dry words and broad stipulations of contracts must be read and interpreted in the light of reason and of the subject contemplated by the parties. The stipulation common to many corporation contracts, that contractors may be required to perform extra work at the price named in the agreement or fixed by an engineer, is limited by the subject-matter of the contract to such proportionally small amounts of extra work as may become necessary to the completion of the undertaking contemplated by the parties when the contract was made; and the work which does not fall within this limitation is new and different from that covered by the agreement, and the contractor may recover the reasonable value thereof, notwithstanding the contract. The customary provisions in such contracts that the corporation or its engineer may make any necessary or desirable alterations in the work, and that the contractor shall receive the contract price or a price fixed by the engineer for the work or materials, required by the alteration, is limited in the same way, by the intention of the parties when the contract was made, to such modifications of the work described in the contract as do not radically change its nature or its cost. Material quantities of work required by such alteration, that are substantially variant in character and cost from that contemplated by the parties when they made their agreement, constitute new and different work, not governed by the agreement, for which the contractors may recover its reasonable value.

I take it that in highway work, and indeed in all contracting work, it is a wise precaution to know that the specifications are in their final form and to know that the plans are in their final form. Too often contracts involving hundreds and thousands or millions of dollars have been made with a recital that "Hereunto attached are plans and specifications covering the proposed work," when as a matter of fact, if it is a highway contract the line has not been run and the specifications have not been typed. A contract executed under such conditions as those can hardly be dignified by the name of contract.

Classification of Materials and Youthful Engineers.—Now, of course, when you run counter to young engineers, your troubles are most serious, if you have the refinements of classification of material. I suppose the most undesirable classification in a highway contract would be this: Solid rock, sand rock, loose rock, cement, gravel hardpan, and common excavation. Now if those specifications also provide that solid rock is that material which can only be removed by blasting, and hardpan is that material which cannot be plowed with six horses or six mules, why you immediately lay the ground for at least differences of opinion with our friend, the young engineer; because when you go to work on the solid rock it may have a fissure here and a fissure there into which it is possible to insert a pick and a crowbar.

The young man may say to you, "What are you using powder there for?"

"Why," you say, "that is because it is the most economical way of getting out the material."

"Well, I am not going to classify that as solid rock," he replies; and you answer, "Why, of course, it is solid rock. The only economical way of getting out that material is by the use of powder." You argue and he argues, and friendly relations cease from that time on. And then you get on to a stretch of territory which he claims is common excavation and which you claim is hardpan, and you say, "That can't be plowed with a team of six horses or six mules." "Why, yes," he says, "it can. Put a man on the plow beam and let him hold it down and you can plow it." Here you differ again and your friendly relations are shattered for a second time. In other words, when you inject the matter of human judgment into the determination of the amount of money which the contractor is going to receive for the doing of a particular piece of work, why under those circumstances you are liable. It does not always happen, but you are in grave danger of running into difficulty.

Of course if the topography of the country permits, and I understand that a good many contracts have been let in Eastern Oregon upon a straight excavation price, that is the most desirable method and the one which will furnish least business for the lawyers. Perhaps it may be that the topography of the country is such that you can have two classifications, common excavation and other excavation.

—Suggestions for Simplifying Difficulties of Classification.—I wonder if I could dare suggest to you a proposal for the adoption of a method of classification which I think is novel. So far as I know this method has never been tried, but I am going to propose it, as the purpose of it is to eliminate differences of opinion with the young engineer. There may be something wrong with it. I am not a contractor, although I have done a great deal of business with them; they have told me their troubles and I have tried to acquire a little of their knowledge.

Would this be possible? We will assume that a piece of work is to be let which is 1,200 stations long. We will assume that it contains solid rock, cement gravel, hardpan, sand rock, and common excavation. The one runs into the other. There is a lot of scratch work here which runs along for a dozen stations and then you come to a bluff, all earth, the finest kind of material for station work that you ever saw, which runs on for three stations. Then you run into a basaltic cliff which runs on for four stations and then it drops off into prairie again and you have scratch work for 300 or 400 other stations. Now would it be possible, through co-operation with the authorities, to divide that 1,200 stations into districts, say four districts, which should average 300 stations each? Let the station from station 0 to station 200 be district No. 1; from station 200 to station 500 be district No. 2; from station 500 to station 1100 be district No. 3; and from 1100 to 1200 be district No. 4. Now let those stations be set apart and designated according to the character of the material and also according to the opportunity, ease, or difficulty of doing the work. I take it that it is just as difficult to excavate six inches of scratch work over a hundred stations, or common excavation over two or three hundred stations, as it is to excavate for a shorter distance a larger amount of material which is harder to work. After you get the stations divided then call for bids and ask for bids in straight prices for districts 1, 2, 3 and 4. Then let the contract be awarded according to the estimate of quantities, multiplied by these straight prices. You absolutely eliminate any possibility of classification; you have a straight price for each of those districts; your competition is preserved because the aggregate of the estimate quantities in those sections multiplied by the straight price will give you the total price on the whole job.

The answer to that perhaps is that you can not look into the earth and see whether the surface formation extends down to the grade of the roadbed; but you have, all of you, signed contracts which have said, "No overbreak will be allowed outside of the slope stakes," and you have done that with a smile when you did not know whether there was going to be an overbreak; and is it not just as easy, in most country, at least in territory where the formation is more or less uniform, to look into the ground at least down to the level of the roadbed, as to look into the brain of an unidentified, unascertained, and as yet unselected engineer in charge of the work?

Operating Data on Large Electric Shovels at Queenstown Development

By L. C. M'LURE.
Industrial Department, Westinghouse Electric & Manufacturing Co.

Records made in excavating the Queenstown-Chippewa power canal by the Hydro-Electric Power Commission of Canada have fully shown the value of large electric shovels. Over 20,000 cu. yd. of earth and rock are removed daily in digging this canal, the major portion of this being accomplished by means of three 8 cu. yd. electric shovels. Not only have the volume records indicated the success of these shovels—which, by the way, are the largest in the world—but the operating economies have also proved conclusively the value of this equipment.

The operating economies were found by making a thorough test on shovel No. 1 while being used as shown in the illustration. This Bucyrus shovel is of 300-ton weight, has a 90-ft. boom, uses either 5, 6 or 8 cu. yd. buckets and works on a 40 to 50-second cycle. There are four Westinghouse 440-volt, 3-phase, 25-cycle motors in this shovel used as follows: Two 250 HP. for hoist, one 150 HP. for thrust and one 150 HP. for swing. The controllers are of the master-switch, magnetic type and the whole operating is handled by two men. This shovel was working 90 ft. below the surface and loading material on cars approximately 70 ft. above their own base.

Tests were made with a graphic wattmeter connected in the 4,000-volt circuit near the shovel. A high-speed clock in the meter allowed the chart paper to pass the pen at the rate of about 5.5 in. per minute. The accompanying chart is a typical load curve of the shovel taken while loading three trains during one morning of the test. A check was made against the chart by noting the starting time of each operation during the entire test. The test covered a period of seven days, work being done only during the daytime for the first five and both day and night for the last two. The results of the test are summarized below:

	Total yardage.	K.W.H.	K.W.H. per yard.
Whole test.......... ...	24,406.5	20,436	0.826
Day work only .. .	15,380.0	12,216	.794
Day and night.............	9,326.5	8,220	.882

From the accompanying table it is seen that the kilowatt hour for each cubic yard dug and lifted 70 ft. and loaded into a car was approximately 0.8.

300-Ton Electric Shovel Working 90 Ft. Below Surface and Loading Cars 70 Ft. Above.

The graphic chart shows the energy consumption under actual working conditions and gives an accurate figure for energy consumption per cubic yard excavated. Fifty seconds were required to make the entire cycle. During this period a maximum power demand of 800 HP. was reached. The average was 320 HP. for the entire cycle.

An interesting feature of the operation of these shovels is the fact that regenerative braking is utilized whenever possible. In this particular instance it is used when the bucket is lowered the 70 ft. after it has been raised that distance in order to load the cars. This is accomplished as follows: When the operator is ready for the bucket to come down, the motors are connected to the power supply and the bucket falls with the motors running at slightly above synchronous speed. When such a conditions is reached, the motors operate as induction generators. Although as can be seen from the curve, some energy is generated and pumped back into the line, this item is not the main feature of this operation. This method of lowering saves mechanical wear and tear as the brakes are required only for stopping and holding the bucket, requiring less repair work and making the whole equipment more reliable.

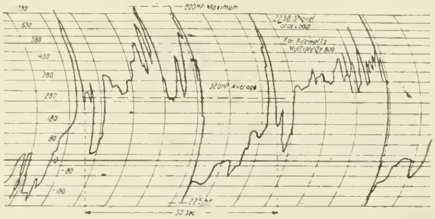


Chart Showing Energy Consumption of Electric Shovel Under Actual Working Conditions.

Grouping Ties for Treatment

A common requirement in the specifications for treating ties is that they shall be sorted or separated into special groups according to absorptive properties, sap-wood content, seasoning properties, or track requirements.

Mr. Hunter J. von Leer in a paper read before the Wood Preservers' Association in Chicago has called attention to certain economic considerations in connection with this matter as follows:

Any separation of ties for the purpose of improving their treatment is unnecessary and contrary to good practice. When such separation is based on the absorptive properties of the wood; when the ties are manufactured from broad leaf trees; when the treatment is to refusal.

To prevent any misconception of its meaning, let us analyze the proposition as submitted. When I say this separation is unnecessary, I mean that there is not and never has been an adequate return for the expense incurred. It carries an additional cost and does not add to the life or service of the ties. The question naturally arises, what is the cost of this separation and the extent of such a waste? Some idea of this may be obtained from the following facts. To begin with, it is cumulative, starting from the time of production and increasing with each movement until installation in track. At all points it is the direct cause of much delay—the principal one being car service. This to railroad men is a most important factor. Again this delay reacts strongly on the plant operator and affects the following items: It complicates an already difficult labor problem and frequently results in a messed-up storage yard. It increases either directly or indirectly each of the following costs incident to plan operation—power, local transportation, equipment and upkeep. It requires additional supervision, and there remains the direct charge for extra handling. We may, therefore, state conservatively that the annual cost of this separation, as practiced by several of our larger systems, will amount to many thousands of dollars.

Power Saving by Roller Bearings on Mine Cars.—In a letter to the Coal Age, Mr. Richard W. Harris states that a test conducted at the Greensberg Coal Co.'s mines showed a saving, in favor of roller-bearing cars, of 47.25 per cent, by the reading of the dynamometer. At another test made at Carbondale, Pa., the average drawbar pull for plain-bearing cars was 32 lb. per ton, as compared with 13 lb. per ton for cars equipped with flexible roller bearings. This test also developed the interesting fact that it takes twice as much power to start plain-bearing cars as is required for those mounted on roller bearings.

Economics of Railway Location As Affected by the Introduction of Electric Locomotives

In a monograph on the above subject, in a recent bulletin of the American Railway Engineering Association, Mr. E. H. McHenry has made an interesting contribution to a matter of increasing interest to railway locating engineers. The principles laid down a generation ago by Mr. A. M. Wellington, and so often quoted and referred to by engineers of today, are still in the main the guiding principles on railway location. In such a radical change of conditions, however, as the change from steam to electric motive power, there are necessarily some modifications in these principles. We quote the following from Mr. McHenry's paper:

First and foremost, the electric motor has a traction rather than a horsepower rating, as its tractive effort varies almost directly with the current supplied, which in turn is sharply limited by the safe maximum temperatures permitted by the motor design. The heat losses which cause the temperature rise, vary directly with time and as the square of the current density, thus introducing new time and temperature elements for which no counterparts are afforded in steam operation.

Following steam nomenclature, the commercial ratings of electric motors are usually expressed in terms of horsepower units, but similar ratings in the two classes of service have little in common but the name, as their characteristics and limitations are very dissimilar.

Unlike the steam engine, the electric motor cannot continuously develop its maximum horsepower and tractive effort, being restricted by its safe temperature limit, but within such limit, its continuous rating may be much exceeded, during short intervals of time.

Also, under certain conditions, the actual capacity of the electric locomotive may considerably exceed its nominal horsepower rating, as with proper methods of voltage control the voltage or speed component of electrical horsepower may be varied without affecting the current or traction component.

These distinctive features of electric operation lead to important results, on both the debit and credit sides of the account. The electric locomotive must be adapted much more closely to the service in which it is to be used, as the range within which its speed-pull characteristics can be varied is generally much narrower than that of a steam locomotive, but this disadvantage, in some types of engines, is compensated in part by the ease with which they can be adapted to either fast or slow train schedules by a simple change of gear ratios.

The low ratio of continuous to maximum horsepower and tractive effort must also be considered as an economic disadvantage.

On the other side of the account, the electric locomotive can sustain a greater tractive effort at higher rates of speed than the inherent limitations of its steam rival permit for reasons previously explained, which is a feature of paramount importance and economic value, as in large measure it avoids the costly sacrifices of train lengths and weights entailed by fast passenger and freight train schedules in steam service.

The cost of fuel is most fundamentally affected, as net savings of 50 per cent, 60 per cent and 67 per cent, respectively, may be expected in passenger, freight and switching service. These high percentages in combination with the large amounts expended for fuel are the chief elements in the economy of electric operation and the amount of the reduction in such charges is usually the determining factor.

Engine repairs are also much reduced, perhaps in a ratio of 50 per cent or more of the equivalent charges in steam operation, but the saving is partially offset by the cost of maintenance and repairs of power stations and sub-stations.

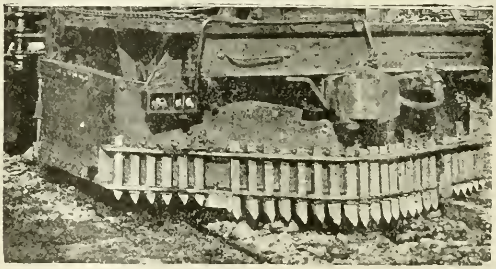
Conditions are simplified and expenditures reduced at engine terminals by the elimination of water tanks, coaling stations, ash pits and turn tables and opportunities are often presented for further reductions in the cost of maintaining such facilities by extending the length of engine runs between district terminals; also all intermediate water and fuel stations may often be abandoned.

The cost of rise and fall will, of course, be reduced if advantage is taken of opportunities for the regeneration of power by trains on descending grades. The value of such regeneration is usually underestimated, but nevertheless is very considerable under proper conditions. Theoretically the amount of power generated in the descent should equal that consumed on the rise, but deductions for rolling friction and the doubled efficiency losses in motors will reduce the available power to a possible maximum approximating 50 per cent. The actual percentage which can be utilized will depend upon the length and steepness of inclines, the total length of the electrified section and the number and distribution of daily trains.

The effect of a change to electric operation as affected by curvature will be in degree rather than in kind, with one possible exception, as the shorter rigid wheel base of some types of electric locomotives will result in reduced resistance and wear of wheels and rails. Such resistance and wear probably varies inversely as the square of the length of rigid wheel base and accordingly even small differences in length may have relatively high economic values.

Ice Cutting Attachment for Jordan Spreader

Snowplows and flanges of various sorts are part of the necessary equipment of any railroad operating in northern latitudes. There are conditions, however, under which these are of little use, as the Canadian Pacific Ry. officials have learned in some recent experiences. When heavy falls of wet snow freeze and turn to ice both on top of and between the rails, snowplows are useless and hand picking is too slow and expensive. The illustration below is taken from the Railway Maintenance Engineer which describes the attachment as follows:



Method of Mounting Chisel Teeth in Channel Frame.

This ice cutting attachment consists of a steel channel frame so designed as to fit snugly over the plow front of a Jordan spreader, where it is held by special bolts without necessitating the removal of any parts from the spreader. The channel contains a series of 29 interchangeable chisels or steel teeth, arranged so that there are 6 on the outside of each rail and 17 between the two. Each chisel is held independently in the frame in such a way that it can be adjusted quickly to regulate the depth of cut below the top of rail, or it can be removed entirely for re-dressing. In this way the chisel teeth can be used for a long time, their term of life being limited only by their overall length and the amount of metal removed on regrinding. Flanged shoes are fastened under the frame and the spreader plow front, which ride the rails in a manner similar to that of a snowplow and, besides doing considerable work in clearing the rail, act as a lining device to keep the attachment well centered between the rails.

The entire construction of the ice-cutting attachment is not ony simple but durable and inexpensive. In actual operation one man controls the spreader, raising and lowering the attachment by means of the air lift on the front plow in order to clear obstructions or to work in and around switches, etc. The results obtained have proved satisfactory in ice, frozen cinders, and similar materials encountered in winter operations at terminals and freight yards, which materials were easily broken out, leaving the rails clean and with a good flange.

Over 20 of these attachments are now in service on the Eastern lines of the Canadian Pacific Ry.

Reminiscences of a Pioneer Railroad Contractor*

By W. O. WINSTON,

Winston Bros. Co., St. Paul, Minn.

The first contract that Winston Brothers took was in 1875. It was a contract for removing snags from the Minnesota River and cutting down overhanging trees. This contract was with the government. We were young in the business, but I don't believe we have ever been any smarter in making a contract than we were in making that first contract of ours.

The government had made an estimate of the number of snags to be removed, the number of overhanging trees; for purposes of comparison they had said there would be 1,000 snags, 1,000 overhanging trees; so many of those snags would be from 4 to 6 in. in diameter, so many would be from 6 to 10 in.—I remember the specifications as though they were yesterday; so many from 10 to 20, so many from 20 to 30, so many from 30 to 36, and so many from 36 to 42 and upwards.

We thought we had better examine the job before we made a bid on it. We went over the job in the fall of the year. We took a boat up the river. We made up our own tabulation. They had a large percentage of snags 36 to 42. We found that was tremendously overestimated. So many snags from 20 to 30—overestimated. So many from 40 to 42 and upwards—overestimated. So we made up our own little tabulation. It was the same with reference to the overhanging trees. As a result of that tabulation, we put in an unbalanced bid; snags, 36 to 42, $1; 4 to 6 in., 6$; 6 to 10, $6. The result of it was we got the job and we were the lowest, under the engineer's estimates. When it came to the finish the other fellows were not in it. It was a fifty-fifty contract, fifty for cost and fifty for profit. We don't get that kind now.

That was a big contract in those days, and the next big contract was on the Northern Pacific R. R., from 1879 to 1883. We began at Mandan and laid the track, built the trestle bridges and surfaced the track from Mandan to a point considerably west of Missoula, Mont.

I was a young man when we first went there. My brother was in charge of the work. Along in 1881, I think, he came over to the western side and started to lay tracks and work from the west to the east, and I took charge of the part from the east to the west, and during that work I had the privilege of having relations with a man named Mitchell. I was about 30 years of age and he was over 60. He had come up from a pipe boy and was a very practical, careful man, and I have been benefited all my life., I think, by my contact with Mr. Mitchell.

To give you a little illustration or a little insight into the man, and his methods of talking to those younger than he was who were trying to do the best they could, I will tell you a few things that occurred. This was during the time my brother had charge of the work. Mr. Mitchell was assistant to the chief engineer. John Anderson was the chief. My brother was away and I met Mr. Mitchell and John Anderson walking on up from a sidetrack to the end of the track where the men were working. Mr. Anderson, the chief engineer, said, "Mitchell, look here at the spike I see some spikes scattered around here. You must talk to Winston about this. Don't let it occur again." Mitchell said, "I have talked to Winston, but, damn him, he doesn't pay any attention to me." Then he turned around to me and says, "Do you know what I think about T. B.?" T. B. was my brother. He was T. B. and I was W. O. I said, "No, Mr. Mitchell, what do you think about him?" "Why," he says, "I think hanging is too good for him; he ought to be kicked."

On another occasion, I don't know what brought it about, whether he thought I needed a little advice, that I was getting a little nervous about things—I don't recall just what brought out the statement, but he said, "Now, Winston, I want to tell you something: don't stand on your head if your feet are in sound condition."

I think that is a pretty good lesson that we should take to heart; we should never get too much rattled. We ought to be composed and do the best we can and not be damaged by fretting.

On another occasion he came to me after having just returned from the front where the grading was going on.

We had a little box car; we lived in box cars; and, by the way, I slept for four years in that box car, the top end of a box car; we built it up and lived in the top end and had an office underneath; and I slept in a bed without any springs, without any sheets, only a tick with some hay in it for a mattress, but no pillow; my coat was my pillow. The room we had to dress in was not big enough for one to stand up straight.

Well, Mitchell asked me, "Winston, can you lay 3 miles of track a day?" We were then laying about an average of 2 miles. "Yes, Mr. Mitchell," I replied, "we can organize to lay 3 miles of track a day." And he said, "Down at St. Paul they want you to lay 3 miles of track a day." "Well, Mr. Mitchell," I said, "we can organize to lay 3 miles of track a day, but it won't be a week, certainly not over 10 days, before we will be up against the graders and have to shut down." "That is just it," he said. "I have just come from the front; I will not ask you to lay 3 miles of track a day. It is all well enough to hurrah, boys, but there is no sense in hurrahing boys if you are going to hurrah your heads up against a stone wall." So that was Mitchell.

On another occasion were were at Bozeman, Mont., and he came into the office and said, "Winston, when do you expect to cross the upper Missouri with the track?"

I forget the distance; maybe 40 or 50 miles. I took out my pencil. We had an elegant organization; you can't get them these days, not on such work. I figured the distance. I knew about the average we were going to lay a day, and I said, "Mr. Mitchell, on the 20th day of May."

"I'll bet you a big apple you don't," he said.

"All right, sir; I will take your bet," I responded.

On the 19th day of May we were 1,000 or 1,500 ft. from that crossing. I said to our track superintendent, Mr. Gilford, generally known as Red Cloud, "Mr. Gilford, I want you to take the men out tomorrow morning, Sunday, and lay across the Missouri River. I have a bet with Mr. Mitchell." So Mr. Gilford called the men out the next morning and laid it across the Missouri River and I won my big apple.

Of course, that is only illustrating the difference between those days and now. You could count very closely, approximately closely on what you could do in a given time with a certain organization. Now you gentlemen know what you can do now—you can't do it.

Now those are just a few of the things that occur to me. This in a rather fragmentary retrospect of the past. One other fact has been made known to me. I had not thought of it; I had forgotten it; it was a fact at which I was surprised myself, and I was gratified, too. And I am going to tell you about this because it, I think, gives us a rather pleasant impression of our friends, the engineers. Of all the relations I have had with the engineers in those 45 years of work there has been only one, for whom I would have been unwilling to do the second job, having done the first. Now I think that speaks well for the engineers.

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*From an address delivered March 3 before First Annual Convention of the Associated General Contractors of the Pacific Northwest

Electrification of South African Railways

The firm of Merz & McLellan, Consulting Engineers, of London, has recently made a report on the proposed electrification of portions of the South African railways. Mr. Robert E. Thayer, European representative of the Railway Electrical Engineer, has made an abstract of this report, from which the following is taken.

It is estimated that to equip 860 miles for electric operation will require an expenditure of $50,000,000. Direct current at 3,000 volts is favored on account of the simple construction of electrical equipment in which the first cost is low and the maintenance easy and cheap. Reference is made to the results of electric operation on the Chicago, Milwaukee & St. Paul Ry. in the western part of the United States, as a practical example of the adaptability of this system.

In spite of the fact that the gage of the railways is 3 ft. 6 in., it has been found possible to design suitable equipment. The report recommends electric freight locomotives weighing 269,000 lb. and having a tractive effort of 48,000 lb. for one hour and 64,000 lb. for short periods such as when starting a train. With the maximum traffic effort a factor of adhesion of 4.2 is obtained. For passenger service a locomotive of 161,280 lb. has been recommended which will have a tractive effort of 30,000 lb., one hour rating, and a maximum tractive effort of 38,400 lb. For shunting service an electric locomotive weighing 125,440 lb. has been recommended of sufficient capacity to exert a tractive effort of about 14,000 lb. at about 12.5 m.p.h., or a maximum tractive effort of about 24,000 lb. For suburban service the multiple unit system made up of combinations of one motor coach with a trailer is suggested. Regenerative braking is recommended for adoption on certain portions of the electrified lines.

The possible use of water power was carefully studied, but the rainfall in South Africa is very irregular and the flow of water in most of the rivers crossed by the portions of the railway under consideration is unreliable and occasionally ceases altogether. Even the Orange and the Vaal rivers have been known to cease flowing altogether and this is a common occurrence with other rivers of less importance. Thus hydro-electric plants are out of the question. Furthermore in South Africa coal at the pit is cheap and the cost of freight is low, which again favors the use of steam-driven generating plants.

Loose Leaf Form for Survey Notes

A convenient loose leaf form for office filing of notes of underground or other surveys is described in a recent issue of the Engineering and Mining Journal:

When properly posted, this form will contain all the data necessary to calculate a connection between any two points in a mine, or to plot any plan, projection or section. The columns marked "Station," "Horizontal Angle," "Inclined Distance," and "Vertical Angle" are filled in from the field-book notes, and the "Bearing" and "Horizontal Distance" are calculated. The spaces in the column marked "H. I." are divided in two horizontally, as indicated.

In the upper half is set down the height of instrument, using the plus or minus sign according as the set-up is over or under the station. In the lower half-space is noted the height of roof above the floor at that set-up. This is of importance in calculating a raise to a certain point in a drift, for example, under a station in the roof. In the column "Height Point," the distance of the point sighted at above or below the station is set down, plus if above, and minus if below (usually minus), for the underground stations, generally speaking, should be in the roof (with a plumb bob suspended for the foresight).

The "Vertical Distance" is calculated from the inclined distance, vertical angle, height of instrument, and height of point, giving the difference in elevation between the station at the set-up and the station sighted. The columns marked "Latitude and Departure" show the difference in latitude and departure between the set-up station and the foresight station, and the "Total Latitude" and "Total Departure" columns show the co-ordinate distances of the stations from the center of co-ordinates. The column "Vertical Co-ordinate" shows the vertical distance of each station above or below the datum plane. The "Remarks" column is used for side notes and sketches of shaft stations and other complicated mine openings.

The form is 12 x 18 in., and punched to fit a post binder. Notes of various levels and of different mines can easily be kept separate, more leaves being added as necessary. A duplicate set of notes can also be kept in a fireproof vault, or sent away if required. With the addition of four columns in the "Remarks" column, this form may also be extended to accommodate level notes.

Working Place **Page No.**

STATION	Horizontal Angle	Bearing	Inclined Distance	Vertical Angle	Horizontal Distance	H. I.	Height Point	Vertical Distance	LATITUDE		DEPARTURE		Total Latitude	Total Departure	Vertical Co-ordinate	REMARKS
									North	South	East	West				
																Surveyor

Loose Leaf Form for Survey Notes.

New Opportunities for the Railway Engineer

The following is quoted from an address by Mr. G. W. Hand, assistant to the president of the Chicago & Northwestern Ry., presented March 5 before the Second Railroad Conference of the American Association of Engineers:

The most important thing for this association to devote its attention to at the present time is the opening up of new channels, places where engineers can utilize their talents that heretofore have not been open to them. On some railroads, of course, the engineers fill positions of all sorts from top to bottom. In other places they are practically confined to purely technical matters. It is on those roads where those things have not been opened up that our attention should be at once centered on the possibilities of getting more things that the engineers can devote their talents to. We are confronted now on the railroads with a new situation. The roads have gone back into private operation with a new law and an entirely new order of things to face. It has occurred to me more than once that engineers now have opportunities that they never had before. One of the very first things I think the engineers should undertake to do is to study this new law, learn all about it and find out what the problems that confront the railroads are, and begin to help to solve them.

Now under this new law that I have just spoken about there are a number of things that it seems to me are peculiarly within the province of engineers to solve. The Interstate Commerce Commission has been given the suggestion from Congress that the railroads should be districted in some way or other for rate-making purposes. Now this question of districting of course is one that will be solved in some way. They don't know how they are going to do it.

The Commission has had one meeting and they suggested three districts for the whole United States. Immediately there was some discussion about it and the people in certain sections of the country thought they ought not to be put in with some other people because the operating conditions in those sections were much easier than they were in some other sections. We can readily see that every section in the United States is going to try, if possible, to get itself into a district where operation will be cheaper than some other section and try to benefit thereby.

I think it is peculiarly a question for engineers to consider how the railroads could be grouped together in districts, where traffic that is dense upon one line can be spread out over others that need additional traffic. It is a question of the co-ordination of terminal facilities, a question of grades, a question of second track and ability to handle things that they don't now handle, and so on. I think every one of us in this section ought to be considering the problem because pretty soon we are going to hear something from the Interstate Commerce Commission about it, and if we have any ideas then to suggest that will be the time. If we don't, why the railroads, the traffic men, will solve the problem, and they will say probably there are some engineering problems involved, but no engineer came forward with any suggestions and we will have to get along without them.

Now then there is another question and that is how the engineer can begin to prepare himself to get into higher positions. Of course the engineer can't be given charge of something that he doesn't know anything about. He has got to learn these questions if he expects to get ahead. We all realize that and I think we feel that at our meetings something ought to be done to stimulate the interest of the engineer, directing his attention along lines that will be beneficial to him. There are certain indexes of the railroad situation, statistics, that are being published and collected monthly. They are collected by roads. They show the condition of things. They show the condition of traffic. They show expense of maintenance, condition of power, and fluctuations. All those things are vitally important and railroad managers of course depend a great deal for their knowledge upon those statistics. I think the railroad engineers should be furnished at their meetings, their local meetings, with the statistics that apply to their roads currently and they should be taught what the significance and meaning of these statistics are, how to interpret them. They should be given current attention so that every engineer just as soon as he starts to work as a rodman, tapeman or anything else, would begin to learn the broader phases of railroading, how it applies to him, and how an engineer, how the engineering department is related to these broader problems.

Then another thing that occurs to me is some arrangement, some way whereby the railroad engineering department, the head of the engineering department and the subordinate officials in the engineering department and the management make some some provisions for the welfare of the young engineer, teach him the advantages of getting started right and of staying with one road as long as possible. I think that is one of the quickest ways to learn all the phases of it, to stay where you get started. Of course, you can't do that unless there are opportunities sufficient to attract a man to keep him there, but the management of the railroad would certainly see the advantage of having the organization changed as little as possible.

Method of Blasting a Standing Tree

By LEO H. SHOLTS.

I recently completed a contract to clear right of way on 24 miles of State and Government aid highway near Cedar Bluffs, Nebr. Some of the trees it was necessary to remove were at least 60 years old and very large. One of these was a sound, healthy cottonwood, 80 ft. tall and measuring over 5 ft. in diameter.

Part of 80-Ft. High, 5-Ft. Diameter Cottonwood Blasted Down by 17 Lb. of Dynamite.

The tree stood almost in the midst of a new telephone system of 20 wires. If the tree had been cut down and the stump blasted there would have been great danger of breaking some of these wires, so I decided to blast the standing tree in spite of the fact that this would take more dynamite than to have blasted the stump.

A lineman climbed the tree and fastened a steel cable near the top. This was run at right angles to the telephone wires out into a field where it was securely anchored after being drawn taut.

The blast lifted the tree a few feet in the air and it was then pulled by the cable over on its side away from the wires, causing no damage whatever.

I used 17 lb. of 60 per cent ammonia dynamite to bring down the tree. The charges were loaded in seven bore holes put down under different sides of the tree. There were 3 lb. in each of the five main holes and 1 lb. in each of two auxiliary holes on the side I found to be most strongly rooted. The charges were connected up in series and fired with a blasting machine. The soil was black loam and clay. Charges were placed deep and tightly tamped.

The illustration shows a part of one of the roots. It reaches up through the wires which are 22 ft. from the ground.

Explosives for the job cost $5.48 and there were 2 hours' labor charged to it.

The Pneumatic Tie Tamper—Rules for Its Use

From some figures given by Mr. W. H. Armstrong, of the Ingersoll-Rand Co., in the Railway Maintenance Engineer, it appears that since its introduction in 1913 the pneumatic tie tamper has grown steadily in favor with railroad men.

The first road to undertake the use of this equipment now has 228 of the Ingersoll-Rand tie tamper outfits in use, while in the country at large some 60 steam roads are now using 4,000 tie tampers for which they are operating about 600 of the compressor car units.

Mr. Armstrong describes some important features of this apparatus and gives some rules for its operation.

In terminals, tunnels and other places on the railroad where pneumatic signal lines are installed, or where permanent air lines are available, the tie tampers can be operated from these lines without the necessity of the auxiliary compressor unit. To obviate any danger of the tampers using so much air as to make the signals inoperative a special valve is provided which cuts off the air from the machine when the pressure drops to the minimum required for safety.

For supplying air at points where a permanent source of air supply is not provided, a portable gasoline-driven compressor unit has been developed, which is mounted on a suitable car and is self-propelled so that it will run under its own power to the place where work is to be performed and there set off to one side of the track. This portable compressor is made in two sizes, one for operating two tampers and the other for operating four tampers. Tie tampers will work under any air pressure of from 60 lb. to 100 lb., but the best results are obtained with an average working pressure of 65 lb. except when they are used for picking concrete; for this work 75 to 80 lb. pressure will give the best results.

The tie tampers should be worked in pairs, one on each side of the tie and opposite each other. They should be held perfectly vertical when starting, with the broad face of the bar against the tie until the face reaches the bottom of the tie. Then both tampers should be swung back at the same time until they are at the proper angle to drive the ballast under the center of the tie. The tampers should be started under the rail and worked to the end of the tie, then lifted back under the rail and worked to about 8 or 12 in. inside the rail. The men should not be allowed to stay too long on one tie, as they will overtamp and hump the track. The average should be about two minutes to a tie, and that is divided, one minute outside of the rail and one minute inside.

If the tie is loose so that it pumps up and down under traffic or if the track is lifted out of face, it is not necessary to rake the ballast out from between the ties, as the tamping bar will work through the ballast. If track is being tamped in face or the tie is fairly solid under traffic, it is desirable to loosen up the ballast with a pick before tamping, and, in some cases, to rake out a little of the ballast, as this enables more speed to be made in tamping.

A workman should not grip the handles tight or ride on the tampers, as it has enough weight so that it will feed itself down. Gripping tight on the handles, throwing the weight on, or riding upon the tool only tends to make it harder on the man and slows up the speed.

When tamping through slip switches or around frogs where the space is contracted, the tamping bar should be inserted through the space with the broad face parallel to the rail and the machine held in a vertical position. After running a few seconds it will displace a sufficient amount of the ballast to permit swinging the tamping bar around so that the broad side parallels the cross tie. One then proceeds just the same as in open work, that is, holding the machine in a vertical position until the tamping bar reaches the bottom of the tie, then swinging back at the proper angle to pack the ballast to under the tie.

The compressor car is placed on the track on the flanged wheels and run under its own power to the point where the tamping is to be done, being protected in transit in the usual method by train order or by flags. It is then removed from the track to a permanent car rest erected on the side of the right of way or to a temporary car rest made of a crib of ties, being rolled sidewise on a transverse truck to the crib on the cross rails which are provided as part of the compressor equipment. This can be done very quickly, as with the two-tool compressor, four men can easily lift one end at a time to insert the cross rails, while with the 4-tool outfit suitable lifting jacks are provided for that purpose. After the car is placed on the car rest the hose lines are run out from the compressor and connected to the tampers and as these hose lines are 300 ft. long it is possible to tamp 300 ft. either way from the compressor, or 600 ft. of track so that at most it will only be necessary to make one move during a day. At the end of the day the plant can be locked up and left on the right of way, or, if preferred, it can be used to carry the crew in to section headquarters.

Solid Chrome Nickel Steel for Special Track Work

The Milwaukee Electric Railway & Light Co. has developed a substitute for solid manganese steel which is described in a recent issue of Electric Railway Journal, from which the following is taken:

The investigation was carried through considerable experimentation, out of which was evolved a chrome nickel steel having a composition which seemed to offer the desired qualities. To date three double-track crossings made up from solid chrome nickel steel castings have been installed and a fourth one is now being made. These embody a number of unique features in connection with the method of construction and installation.

The formula finally determined upon for this special work steel was as follows:

	Per cent.
Carbon	0.35
Manganese	1.00
Phosphorus	0.03 (max.)
Sulphur	0.04 (max.)
Silicon	0.15
Chromium	0.55 to 0.60
Nickel	2.30 to 2.50

The crossing for each single track was cast in four pieces (four crosses) in order that the machining could be done on the largest planer available in the company's shops. If a large enough planer were available it would be desirable to cast each single-track crossing in only two pieces, thus avoiding two joints. The castings were made in a local steel foundry in basic electric furnaces and all machine work was done in the company's own shops, though now that the development work has been completed an effort will be made to have future special work built by manufacturers.

After the machine work was completed the four pieces for one single-track crossing were thermit welded together in the shop at the four joints and then two of these complete crossings welded together at their two joints. This half-double crossing was then through-bolted in the shop to 8-in. x 8-in. and 8-in. by 12-in. white oak timbers, the larger timbers being used for those positions coming directly under the rails, in order to give a width outside the rail base sufficient for the bolt holes and rail clips. A double-track crossing with its foundation was thus made up and transported to the location at which it was to be installed in two pieces, so that of the 40 joint welds to be made only 20 had to be made in the field.

All joints were thermit welded, not a single bolted joint being used.

The chrome-nickel steel crossings are flange bearing throughout. This has proved to be a very desirable feature as it tends toward a lower maintenance cost and produces an almost noiseless and smooth riding crossing. Sufficient metal was left in the flangeway to permit a wear of $\frac{1}{4}$ in. before the tread of the standard wheel will touch the rail head. When wear in the flangeway nears this limit, it will be a simple matter to build up the flangeway by welding and the operation can be repeated many times over, thus assuring long service with a minimum of maintenance.

The advantages apparent so far in the construction are as follows:

1. Saving of time in installation.
2. Saving in cost of making ends for joints.
3. Eliminates joint plates which were found to wear into manganese rail.
4. Throatways can be welded to make up for appreciable wear.
5. A comparatively smooth riding and noiseless crossing.
6. The material can be both welded and machined.

Essentials in Steel Specifications

Mr. F. A. Weymouth, sales metallurgist of the Bethlehem Steel Co., in a paper presented before the New Egland Railroad Club, emphasized certain points in steel specifications which have furnished discussion and some contention between steel manufacturers and steel buyers. He puts particular emphasis upon the idea that service requirements should be the basic principle in specifications. We quote as follows from his paper:

Our whole economic situation in regard to steel usage needs careful attention. Hundreds of thousands of tons of steel that have just missed meeting the requirements of a high-grade steel by a small margin are scrapped, when such steel should be in service somewhere. This loss must be paid for, and it is certainly our duty to find uses for as much of the steel produced as we can, without in any way sacrificing the safety of our structures.

Conversely, an engineer is very short-sighted who does not recommend an article or type of steel that will give him longer life when that life is necessary, even at an advance in cost. Unfortunately, the railroad engineers have been greatly hampered in that they sometimes have very little control of purchases. Since everybody seems to be suggesting so-called remedies to be applied to the railroads, I may be pardoned if I were to suggest one change that would be reflected at once in maintenance and operating costs, and that is, "Give the engineers and master mechanics full charge over purchases of the materials they use."

In drawing up a specification, consideration should be given to previous experience of our own or of others using material for a similar purpose, together with information from the manufacturers, who not only have accurate, reliable information in regard to the physical properties of all grades of steel, but considerable data as to the use of various grades of steel for difficult purposes.

Keeping in mind the basic principle that a specification should be so drawn up that the material made under it is suitable for the service required, we come to the necessary details that should be embodied.

First: Design or size of material.

This is almost entirely within the hands of the consumer and is of course linked closely with the grade of steel specified.

Second: Grade of material.

Here we must have all the information that is available as to past performance of our own or others, together with our knowledge of the properties of steel under various heat treatments. Under this heading the first consideration should be given to—

(a) Physical properties; and if necessary, to

(b) Chemical properties.

Too much emphasis cannot be given to the fact that it is the physical result we are all looking for and not the composition. If a piece of steel has the necessary hardness, strength and ductility, and is of the proper shape and size, we should not concern ourselves with how it is made or what it is made of. A steel of a certain chemical composition, of a certain size, given a certain heat treatment, has absolutely definite physical properties, so that in specifying the physical result desired we are indirectly specifying the chemical composition.

There is a great tendency in the country to specify not only a physical test, but a chemical requirement as well, with the hope that both requirements will coincide.

During the war it was very interesting to note that our foreign allies had in their specifications very little reference to chemical composition, and placed very little importance on what few chemical requirements they did have, but when they began to place orders in this country they reluctantly added to their specifications a chemical requirement, thinking that the American manufacturers wished both requirements.

It is needless to state that the manufacturers worked to the original specification which required rigid physical properties with very little reference to chemical limits.

This one feature of the foreign specification made possible the enormous tonnage of steel of all grades supplied to our Allies and this steel met the severe war service satisfactorily.

In many cases it is desirable to buy steel on chemistry alone, but when a physical requirement is specified, it is rarely necessary to include the chemical requirement except, perhaps, the maximum phosphorus content, and in rare cases the maximum sulphur content.

The scarcity of the high-grade ores and low sulphur fuels prevents the manufacturer today from producing the extremely low contents of phosphorus and sulphur sometimes required. Extensive investigations have been made and are now being made to show the effect of different percentages of those elements. We find that phosphorus is not an element that produces brittleness, as has usually been the consensus of opinion, but a hardener more intense than the carbon, but acting in the same manner. In other words, we can use higher phosphorus steels if we conmpensate for this hardness by a reduction in the carbon content.

As to sulphur, we are very thoroughly convinced that in almost all cases, even in such steel as rivets, which would show the effect of hot brittleness the quickest, steel with sulphur much above the present standard requirement gives satisfaction in every respect.

After the design, size and shape of the material and the physical properties or chemical requirements, or a reasonable combination of both, are specified, sufficient tests of a suitable nature should be required. Many times we find that parts subjected to abrasion only are brought on a tensile requirement, so here again we must keep in mind the ultimate use of our product. Rolling tolerances should be stated clearly in a specification, but clauses as to length, percentage of second-quality material accepted, et cetera, would best be part of the contract.

The ideal specification from the standpoint of the customer is the clear, concise, brief specification executed by an inspector who has sufficient knowledge of the ultimate use of the material to intelligently interpret the specification.

It must be remembered that no specification can be drawn up which, in the hands of an inspector who knows nothing but what is written in this specification, will deliver accepted material that will be satisfactory to the user.

To summarize:

First: The grade of material specified should be that which experience has shown is satisfactory in service.

Second: Draw up your specification so that for important parts, high-grade material is required, and for parts of lesser importance steel of lower requirements, keeping in mind that it is our duty to make an economic use of steel.

Third: Turn a deaf ear to the traditions on the mysterious, disastrous effect of small percentages of various elements in steel.

Fourth: Confine your specification to a brief statement of the grade of material required, omitting those clauses that are primarily a part of the contract.

Fifth: Place your specification in the hands of a competent inspector who has some authority other than that written in the specification.

Sixth: For your own protection and peace of mind, do not tell the manufacturer how to make your steel and then try to hold him responsible for its behavior in service.

Motor Truck Lines Operated by An Interurban Electric Railway

Some interesting facts concerning an example of electric railway business indicated in the title above are given in a recent issue of Electric Traction. The account should be of interest to those people who have claimed that a similar proposition would in many cases be a "life saver" to small, struggling steam railway lines which too often have had a precarious existence.

As an experiment to determine the practicability of motor truck lines acting as feeders to electric interurbans The Milwaukee Electric Railway & Light Co., Milwaukee, Wis., established during 1919, a motor truck line to several business centers beyond the terminal of one of its branch lines. The idea of the truck line was to reach directly a number of towns that were not served by direct transportation to Milwaukee and to thus provide a new service to those business centers and increase the haulage of express over the interurban lines. The operation of the trial line was so successful that plans were immediately made for the extension of the service by means of motor trucks beyond the terminals of other branches.

The motor truck equipment consists of two 3½-ton solid-tire trucks, 10 2½-ton pneumatic-tire trucks, 3 3½-ton solid tire equipments and 5 trailers; all of which are fitted with weatherproof solid side bodies for the protection of shipments. The pneumatic-tire equipment is favored over the roads on which the trucks make their runs.

The company has developed its own classification for express shipments. The classification is somewhat of a combination of the Western classification and the American Railway Express classification.

During the month of December approximately 5,800,000 lb. of express matter was handled, exclusive of milk, which amounted to approximately 1,800,000 lb. The growth of the business in 1919 was 62 per cent over the year 1918, and the year 1918 showed a growth of 107.5 per cent over the year 1917. During the month of December 1919 truck lines handled approximately 2,000,000 lb., of which 1,200,000 lb. represented a rail haul, the remainder being shipments intercity between truck line points.

The Sixth Annual Convention of the American Association of Engineers

The outstanding sentiment of the delegates and other members attending the annual convention of the American Association of Engineers in St. Louis May 10 and 11 was a desire for building up strong chapters of the association and for decentralization of some of the business functions.

The decision to appoint a board of trustees to consider acquiring a national engineering building in Chicago was the first business transacted by the convention. The building program will be formulated by the board of trustees and formally approved by the board of directors. It was announced that the City Hall Square building in Chicago might be purchased.

The same board of trustees will also consider the proposition of providing group insurance for members of the association, in accordance with a resolution introduced by Garrison Babcock, a consulting telephone engineer of Chicago.

Salaries of teachers in engineering colleges in the United States were recommended tentatively by A. N. Johnson, consulting highway engineer of the Portland Cement Association of Chicago, and Daniel L. Turner, chief engineer of the Transit Construction Commission of New York City, reporting for the committee on salaries of engineers in teaching service, of which Professor C. J. Tilden of Yale University is chairman. The dean of an engineering college is recommended for a salary of from $8,000 to $15,000 per annum depending on the size of the college; professors, $5,000 to $12,000; associate professor, $4,000 to $9,000; assistant professor, $3,600 to $7,500; instructor, $3,000 to $4,000; assistant instructor, $1,800 to $2,400.

Unionism in the engineering profession was strongly condemned in a resolution endorsing a statement issued by the board of directors of the association, reading in part as follows: "We believe in organized representation for the correction of wrong, the advancement of the engineering profession, and service to the public, but are opposed to methods inconsistent with the dignity of the profession and which would lessen public confidence in engineers. The American Association of Engineers, recognizing the many fundamental differences between the principles and objectives of the trade union and an organization of professional men, expresses the opinion that an engineer cannot subscribe to the tenets of both." The resolution recommended the expulsion from the association of engineers who advocate strikes or similar methods of securing their ends.

The association also decided to ask candidates for the presidency to declare themselves for or against the proposed national department of public works, for or against a national budget, for or against a constructive program of conservation of natural resources; and for or against reclamation of waste lands.

Another resolution declared that "adequate highway transportation is a prime requisite for the proper development of all sections of our country," and urged encouragement of worthy highway projects and the continuation of appropriations by Congress as Federal aid.

The immediate restriction of the exportation of such natural products as petroleum and its products, wood and woodpulp, paper, etc., will be urged upon Congress as a means of conserving the natural resources of the country.

"One of the most important means of stabilizing conditions and values lies in greater individual application and industry," reads another resolution, and it was enthusiastically adopted with a pledge that each member would direct his efforts toward the end aimed at by the resolution.

The scheme of Secretary of Agriculture Meridith for the utilization of timber reserves of Alaska for the manufacture of wood-pulp for paper was endorsed as a feasible method of reducing the shortage of print and other paper. The association pledged itself to aid in this project in every way possible.

The legislature of Delaware was urged to adopt the suffrage amendment to the Federal constitution.

To establish the supremacy of the United States in airship development, a resolution was adopted urging Congress to enact legislation authorizing Federal development of aircraft on a large scale or the construction of aircraft by subsidizing commercial organizations.

The following officers of the association were elected for the present year: President, L. K. Sherman, president of the U. S. Housing Corporation of Washington; vice-presidents, H. O. Garman, chief engineer of the public service commission of Indiana, Indianapolis, and A. B. McDaniel, principal engineer of the construction division of the army, Washington; directors, Edmund T. Perkins, consulting drainage engineer of Chicago; Charles A. Finley, managing engineer of the water bureau of the city of Pittsburgh; W. C. Bolin, an engineer with the Baltimore and Ohio Railroad of Chicago; B. A. Bertenshaw, valuation engineer of the Big Four Railroad, Cincinnati; Professor Frederic Bass of the University of Minnesota, Minneapolis; and R. W. Barnes, principal assistant engineer of the Southern Pacific Railroad, Portland, Oregon. Retiring President F. H. Newell, head of the department of civil engineering in the University of Illinois, becomes a member of the board of directors automatically. The following directors hold over another year: Raymond Burnham, consulting engineer of Chicago; E. F. Collins, civil engineer of St. Louis; P. E. Harroun, consulting engineer of San Francisco; A. A. Matthews, chief engineer of the St. Louis and Southwestern Railroad; and F. D. Richards, consulting engineer of Cleveland, Ohio.

The next convention will be held in Buffalo, N. Y.

Effect of Soil Moisture on Efficiency of Explosives in Stump Blasting

Field experiments in the use of dynamite in land clearing made by the College of Agriculture of the University of Wisconsin show that there is a decided advantage in blasting in the spring or other wet period of the year.

The results of the experiments showed that it cost about 50 per cent more to remove stumps during the dry part of the summer than in the late fall when the soil was wet, other conditions being the same.

The plots selected originally were timbered with mixed hardwood timber which had been cut six years. In each plot the average size of the stumps was 15 in. The soil was the Kennan silt loam at North Crandon, Forest County. The land was level and well drained.

All of the stumps were completely blasted for hand piling. Piling labor cost at the rate of 10.5 ct. per stump. Where an additional charge of dynamite was required to complete the removal, it is included in the costs in the table below. "Twenty per cent" dynamite was figured at 16 ct. a pound and electric caps at 8 ct. each. Labor was fixed at 25 ct. an hour. The following table gives the comparative costs of stump removal by dynamite in dry and wet soils:

Item.	Dry (August).	Wet (October).
Number of stumps blasted.	75	102
Dynamite used, lb.........	133.75	99.5
Number of detonators .	123	112
Hours of labor...	39	46.5
Cost per stump:	Cents.	Cents.
Dynamite	28.53	16.6
Detonator ..	13.12	8.78
Labor	13	11.4
Total	54.65	36.78

The work was done in 1917 by the land-cleaning crew of the college of agriculture. During July but little rain had fallen, so that the soil was very dry for the August stumping. From Aug. 7 to October the rainfall amounted to 8.03 in. Much of this fell shortly before Oct. 26, so that for the late fall stumping the soil was reasonably wet.

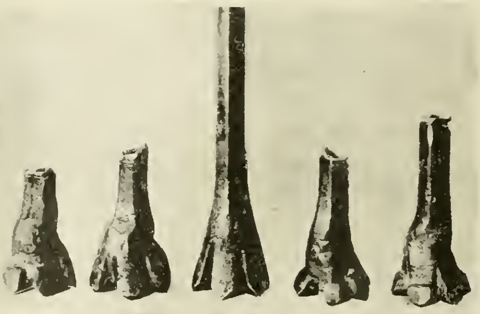
There was a saving in dynamite, detonators, and labor under the wet conditions. The moisture facilitated the making of the holes for placing the dynamite. The advantage of blasting in the spring, or at some other wet period of the year, may amount to $20 an acre where there are 100 stumps or more to the acre.

The Blacksmith and Good Drill Bits

By D. E. DUNN.

Manufacturers of rock drilling machinery can and do make good rock drills and drill steel sharpeners. However, they can naver eliminate the personal equation of the blacksmith. It would seem that the most uninformed persons would realize that the success in rock drilling is almost entirely dependent on the blacksmith turning out good steels. The drill steel sharpener has gone a long ways toward improving the quality of bits made. However, even with this improved and special machine proper bits can be made only with a little care and judgment on the part of the blacksmith.

One of the largest manufacturers of rock drilling machinery not long ago had a complaint that one of its jackhamers was falling down on the job; in the customer's own words, "The drill didn't have any pep." One of the company's representatives investigated this case. The accompanying illustration shows the actual condition of the bits that were used in this mine. The bit shown in the center was made by this representative with the same machine as the other four bits shown, demonstrating clearly that it was not the fault of the sharpening machine. Is it any wonder that the jackhamer didn't have any pep?



Why the Drill Had Lost Its "Pep."

It is found that a large number of drill complaints can be traced directly to bad blacksmithing against which the manufacturers are waging a continual campaign of education. It illustrates also the problem that the representatives of mining machinery companies are frequently confronted with; that is, complaints and dissatisfaction of sincere but not thoroughly informed operators.

Automobile Exhaust Gases in Vehicular Tunnels

The rapidly increasing use of motor vehicles and trucks in the United States is creating an entirely new problem in the proper ventilation of tunnels, subways and other confined spaces through which such machines must pass. This problem has become of immediate importance because a tunnel 8,000 ft. long is being designed to pass under the Hudson River between New York City and New Jersey. Another tunnel at Pittsburgh, 5,700 ft. long, through the South Hills, is already under construction, and a third tunnel, 6,000 ft. long, between Boston and East Boston, is proposed. It is probable that other tunnels will be started in various parts of the United States in the near future.

In order to obtain information as to the amount and composition of automobile exhaust gases, the U. S. Bureau of Mines has undertaken to make tests at its Pittsburgh station, on a number of passanger cars and trucks, about 100 in all. The expense of carrying out the work is being borne by the New York and New New Jersey State Bridge & Tunnel Commissions, who need the information for designing the tunnels under the Hudson River. Pittsburgh is also contributing to the work by furnishing the necessary cars and trucks for making the tests, as the local need for the information is great, to insure adequate ventilation for the tunnel under the South Hills. The work on this problem was started last December.

In order to properly calculate the amount of air that is needed to sweep out exhaust gases from a tunnel, engineers must know what is the largest allowable percentage of carbon monoxide that a person may breathe for several hours without any ill effects whatsoever. This problem is also being investigated by the Bureau of Mines. The work is carried on by Dr. Yandell Henderson, of the Bureau, at the Physiological Laboratory of the Yale Medical School, New Haven, Conn. He is determining just how many parts of carbon monoxide in 10,000 parts of air may be considered safe.

At the present time, authorities differ somewhat in this respect Practically all of them agree that 1 to 3 parts in 10,000 are perfectly safe for at least an hour. A few authorities believe that even 5 or 6 parts may be safely tolerated. The work being done by the Bureau of Mines should determine which figure shall be used. These tests are made by subjecting a large number of people, who volunteer themselves for test, to air containing these small percentages of carbon monoxide.

Osgood 18 Steam Shovel Now Equipped with Continuous Tread Truck

The Osgood Co., Marion, O., has recently brought out a continuous tread truck for its Osgood 18¾-yd. revolving steam shovel. The continuous tread trucks are interchangeable with the traction wheel trucks and are easily attached to the underside of the cast steel truck frame. The outfit, which is very compact so as to interfere as little as possible with the operation of the dipper, consists of two endless tread belts carried by adjustable cast steel side frames which are joined by two cross axles and with the truck frame resting on the axles. The treads are composed of pressed steel pans with oak filling, bolted to heavy cast steel links connected by hardened steel pins and passing around octagonal tumblers at the ends and supported on the bearing side by large rollers or wheels. Power for traveling is taken from a cross shaft underneath the truck frame to the driving tumblers on each side by means of two heavy sprocket chains, the chain being engaged to the driving tumblers with jaw clutches and are readily disengaged for steering. A simple locking device is provided for the two disengaged tread belt which insures a short turning radius when required. All castings in the continuous tread trucks are of open hearth steel and all shafting and axles of forged steel.

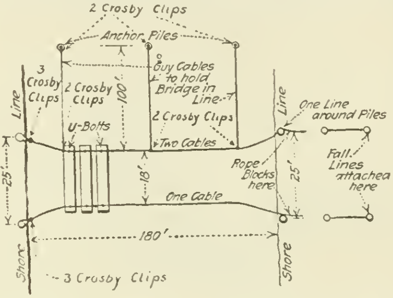
Osgood Continuous Tread Revolving Steam Shovel, Owned by Bentz Bros., Columbus, O., Working at Mogadore, O.

Floating Suspension Bridge for Moving Drag Line Across River

A 70-ton dragline excavator used in ditching operations on the Rio Grande Project of the U. S. Reclamation Service, was moved across the Rio Grande River on a specially constructed floating suspension bridge, built under the direction of Mr. N. S. Fordham, Master Mechanic of the Project. The following account of the bridge is abstracted from The Crosby Clipper:

At the point where it was desired to cross the river there are two channels, with a shoal between; about 800 ft. in all. The channel on the west side carries most of the water, which varies in depth from 18 in. at the edges to 40 in. at the deepest point.

Piles were driven in either bank and two ¾-in. cables were stretched between them. These cables were drawn taut with a set of double blocks and fastened with "Crosby" clips. Across these parallel cables was laid a floor of 6x16-in. timbers 20 ft. long. These timbers were spaced 6 in. apart. The timbers were fastened to the cables with ⅝-in. U-bolts. About 67 timbers were used in the bridge. Three anchor piles driven upstream from the bridge and secured to it with wire rope fastened with clips, held the bridge in line.



Sketch Showing Arrangement of Floating Suspension Bridge.

After the dragline machine had negotiated the bridge it "waded" the shallow channel, traveling over a track made of timbers fastened together with wire rope, which it laid and picked up as it moved ahead. This portable track system was also used when passing over soft ground.

A Severe "Test" of a Motor Truck

What happens when you dump red hot cinders on ice is quite clearly shown in the accompanying illustration. Incidentally, the accident furnished a somewhat "strenuous test" of the truck.

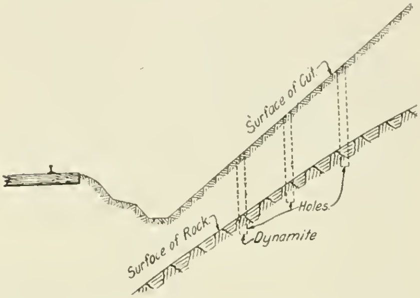
The Walworth Co. of Kewanee, Ill., the owner of the truck, a "Diamond T," makes metal products necessitating the use of sulphuric and other acids. An adjacent pond has been the recipient of hundreds of gallons of these waste acids for a number of years. Among its other duties the truck was engaged in hauling and dumping ashes to fill in this so-called acid pond. During the winter it was the custom to drive the load out on the ice and dump, which worked admirably until the driver unwittingly happened to carry out a load of red hot cinders fresh from the boilers. The hot cinders went through the ice with a splash followed by truck et al.

The rear part was immersed about 72 hours and the motor about 6 hours, or, in other words, long enough to quite thoroughly complete the test. It took a crew of 15 men three days to get the truck out of the "acid pond." The truck is today in excellent running condition and it was only necessary to give it a general cleaning, put clean gasoline in the tank, new oil in the engine and let the coil dry out; all of which was done in six hours.

Motor Truck in "Acid Pond."

Methods of Stopping Earth Slides in Railway Cuts

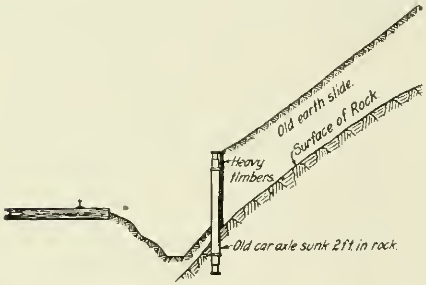
Mr. C. H. Carpenter, writing in the Railway Maintenance Engineer, reminds us that one of the most troublesome kinds of slides is that where a comparatively shallow depth of loose material tends to slide on the rock surface on which it rests.



Preventing Slide by Breaking Up Inclined Rock Surface, Giving Sliding Earth a Better Hold.

Two diagrams are reproduced herewith illustrating methods of dealing with this particular condition.

An earth slide over a slope of stone that gave trouble for a long time was finally stopped by sinking two old car axles upright 2 ft. into the stone slope and laying a few heavy timbers behind them.



Stopping Slide by Barrier Made of Plank Supported by Old Car Axles.

Southern California Edison Company Rate Case

By a recent decision the Railroad Commission of California has established a record for promptly meeting an emergency condition threatening the credit of one of the large electric utilities of the state, and demonstrated the soundness of public regulations and the mutual interest of investors and consumers alike, in maintaining the public utilities in sound financial condition to permit of financing for new development.

The unexpected subnormal rainfall conditions in California this year, making three successive years of subnormal precipitation, have seriously affected the output of hydro-electric plants in the state, causing unusual increases in operating expenses to make up the deficiency. Because of this the Southern California Edison Co. on Feb. 27, 1920, filed with the Railroad Commission an application for a temporary increase in its rates. Hearings were held in Los Angeles March 25, 26th, 27th and 31st, at which all of the cities and farming communities served by the company in Southern California were ably represented by counsel to the number of 34 and the company's case was presented by Gen. Counsel Roy V. Reppy, Vice-President and General Manager R. H. Ballard, Vice-President in Charge of Finance A. N. Kemp, Vice-President in Charge of Business Development S. M. Kennedy, Mechanical and Electrical Engineer H. A. Barre and Assistant Comptroller D. M. Trott. At the conclusion of the hearings, the commission allowed one week's time to protestants during which they might file in writing with the commission any further protests they desired to make.

Under date of April 15, the Commission handed down a lengthy decision allowing the company a temporary increase in all its rates of 27 per cent from April 20, 1920, to Jan. 20, 1921. This increase provides the company with an additional revenue during the period of $2,106,600, in partial complance with the company's application for a 32½ per cent temporary increase. The temporary rates will be in effect, pending the establishment by the Commission of standard rates after a full and complete valuation of the company's properties and investigation of its affairs.

The text of the decision says, in part.:

> It is vitally necessary for the continued growth and prosperity of the vast territory in Southern California supplied by applicant with electric energy that its full programme of development go forward without serious interruption. We believe it to be in the interest of the consumers that they pay rates sufficiently reasonable to enable the company to earn a fair and reasonable return upon the actual investment. Unless this is done, it is plain that the utility cannot borrow sufficient funds to carry forward necessary developments. It is of great importance that this programme of development go forward. Should there be any halt in this programme it is evident that tremendous losses will result to the whole community, if sufficient electric energy is not developed to meet the growing demands. It is becoming increasingly evident that the business life of a community such as Southern California is in a very large measure dependent for its growth and expansion, and in some instances even its continued operation, upon eletric energy, and as the cost of steam generation is constantly increasing the necessity for the cheaper production of electricity by hydro-electric development has become more and more recognized. Of course, it is not to be understood that the Railroad Commission urges the payment of unreasonable rates to stimulate investment in this public utility, but when it is considered that to place this company in a position where it can successfully finance will not result at this time in even an 8 per cent return on investment, it will at once be realized that the burden upon the consumer is not unreasonable. In considerig the granting of an increase in rates of the amount herein contemplated, we are especially mindful of the fact that applicant has been diligently active in the enlarging of its production and transmission facilities since the consolidation of the properties in 1917. It has shown an active determination to carry on development, and from the evidence presented has exerted every reasonable effort to meet the demands of the territory served in the face of difficulties arising from the war period of 1918 and period of readjustment and high cost of money, material and labor which have continued since. Applicant's evidence shows that it has definite plans for the development of both water and steam power for at least eight years in the future at an estimated cost of $100,000,000.

Relation Between Population and Traffic Volume

In a paper presented May 12 before the joint meeting of the American Institute of Electrical Engineers and the Western Society of Engineers, Mr. James Rowland Bibbins, Supervising Engineer, the Arnold Co., called attention to the curiously definite relation between the population and the amount contributed annually to the support of transit investment and service. The riding habit determines first and last the possibilities of development because it controls the revenue. This riding habit increases as the city grows and density of settlement increase. The law is complex, but individual cases are usually consistent. Thus the riding habit of a number of the large cities since electric railways came into existence, has steadily increased from around 200 revenue rides per capita to 350 or more; Manhattan Island approaches 400 rides per capita.

If this riding habit continued to increase roughly in proportion to the population, the ultimate traffic volume would eventually become enormous, because of the geometric progression involved. So some authorities claim 400 rides to be a conservative limit, but time alone can tell; it is more than probable that the epoch of electric development has had a controlling effect. The author cannot find indications of any such abrupt cessation.

Expressed in pre-war dollars, the "riding habit" means that in moderate sized cities the people contribute at least $10 per capita per year for local transportation; in the larger cities and in those unusually dependent upon transportation, such as San Francisco, from $15.00 to $20.00 per capita.

An analysis of a large number of these cities revealed the astounding fact that transportation earnings had increased about as the square of the population, which means that when the population doubles, transit earnings quadruple. New York for many decades has held to this law, with occasional variations. But here again, the epoch of electricity is involved, and looking into the future, it seems certain that various causes will conspire to moderate this geometric rate of increase, such as periods of financial depression, wars, etc. But the plain fact stands out in every case, that transportation service must be had, and this represents an indirect prior tax on the entire community. This is the yard stick by which to measure the financial possibilities of a complete transit system; conversely, any utility expanding beyond the demand for it, is doomed to long years of deficits if not early failure.

To this source of income or taxation should be added the suburban railroad fares and the revenues of jitneys and bus lines. Some steam suburban service yields $10 per capita, as in Pittsburgh; this is probably exceeded in New York, Philadelphia and Boston. As the average family consists of 4.5 persons the total tax on the wage earner or head of family may exceed $100 per year.

Instruction in Business Administration in Technical School

That there is a general movement in the technical schools and colleges toward the teaching of business administration to engineering students, is brought out in a recent report of the U S. Commissioner of Education based on the replies to letters sent out to a number of the larger colleges and universities requesting "a statement of present practice and any change contemplated in courses of study in engineering and commerce." Fifty-five replies were received, a study of which brings out some interesting facts, which are summarized as follows in the Journal of the American Society of Mechanical Engineers.

Approximately a third of the replies received came from colleges or universities which offer subjects in economics and business administration in connection with their engineering courses. In general the curricula provide business training in greater or lesser amounts for engineers who expect to enter positions concerned with the management or administration of manufacturing, construction, and transportation enterprises, which demand a knowledge of business as well as of scientific and engineering principles.

There are several institutions in which the combined business and engineering course is already well developed. For over 20 years Stevens Institute of Technology has given its students instruction in the commercial or business side of engineering. Dartmouth College has offered for four years a course in engineering management. A unique feature of this course is the large requirement in outside reading covering thirty or more books on the subject. The University of North Dakota has offered for three years a course in general engineering, providing about 60 per cent of the work along fundamental subjects in sciences, mathematics and technical engineering and about 40 per cent in subjects relating to both business and engineering careers.

Massachusetts Institute of Technology gives a course in engineering administration which combines instruction in general engineering studies and in the methods, economics and law of business. The course includes (1) the instruction common to all courses, in literature, language, and history, and in chemistry, physics and mathematics; (2) a choice of engineering studies classified under three options: civil engineering, mechanical and electrical engineering, chemical engineering; and (3) a selected group of subjects in business and economics.

Other colleges which do not cover as much ground in their prescribed course, offer these subjects as electives or, in a few cases, in a special fifth-year course devoted to business administration.

There is only one institution reported in which no course is offered in either commercial or industrial engineering. A few commercial schools include engineering subjects in their courses.

The balance of the reports come from institutions which although they do not now offer a combined course, nevertheless are in favor of doing so as soon as they feel that the demand is great enough. Some of them are now at work on new engineering curricula covering a four, five, or six-year combined course. Columbia University, for instance, plans to have in the near future a course in manufacturing and industrial engineering, and Tulane University, New Orleans, now has under consideration a revision of its engineering curriculum to provide proper business training for engineers.

Progress in Design of Curved Heads for Grooved Girder Rails

Editorial in Electric Railway Journal.

Interest has been renewed of late in the subject of curved-head rails through the assignment of the subject to the committee on way matters, jointly with the committee on equipment. While the thought was expressed, when this subject first came up, that there was a possibility that a suitable curved-head design might eliminate corrugation, the principal claims made for the design were more along lines of the possibilities of securing greater life both of rails and wheels through the lessening of the rates of wear.

It is now well established that corrugation is not prevented by this change in design. It has been observed, however, that where these rails have been in service, the length of time within which corrugation first appears has been extended from the few days or weeks formerly experienced to a period of about two years. Perhaps this observation may be construed as indicative of a greatly lessened rate of wear. In any event it is of sufficient moment to warrant the adoption of the curved head as a principle of design. Meanwhile, in its report last year the way committee presented several other good reasons in support of the correctness of the curved-head principle.

Having accepted the view that the principle is correct, there remains the question of detailed application to the existing standard grooved girder rails of the association. The problem thus resolves itself into a determination of the proper contour which will be suitable to wide application, since the standard rail is intended for use throughout the country. An examination of existing designs of curved heads discloses the tendency, on widely separated properties, toward the use of a contour which takes the form of a compound curve, having an initial radius of 12 in. starting at or near the back of the head, an intermediate radius of about 1½ in. and a final radius at the gage-line fillet of ⅝ in. This is in substantial agreement with British designs which have been in service for some years. There is every reason to believe that the average contours of both worn rails and worn wheels are so nearly alike upon different properties that the committee should be able to settle upon a design which will approximate the average wear so closely that it may be readily accepted, and we are inclined to the view that the form of contour substantially as above outlined should be selected.

Setting Slope Stakes

(From the January, 1920, monthly report of the Department of Public Works of Nebraska.)

"What is that, Mother?"
"The Rodman, my child.
His footsteps are weary, his accents are wild.
His hair how disordered, his eyeballs how blear!
And see, there his necktie hangs under his ear!"
"Rod up there! Hold her steady. Go on down the hill!
7.8 cut 2.2—No, begosh it's a fill!
Half the roadbed, 13 plus the slope one to one,
No, it's one and a half, though, as sure as a gun.
Well, that makes, let's see—O stick her in there.
It'll do, perhaps the contractor will swear.
But no difference—we're the big dog in the fight,
No matter what's wrong, just swear it's all right,
A contractor don't know beefsteak from bone,
Now pick up your tools, and let's pull out for home."

Permanent Type of Check Dam in Southern California

Check dams of a permanent type of reinforced concrete construction have been successfully used to control storm waters out of the foothills in Ventura county and to prevent extensive erosion which in the past has ruined many acres of valuable tableland.

A general description of this type of dam is given in a recent issue of the Southwest Builder and Contractor, from which the following notes are taken:

In places where the fall is 3 or 4 per cent and greater, the storm waters have cut deep narrow channels in the valuable flat lands above, some channels reaching a depth of 50 ft., and if not controlled become deeper and wider every year. The banks and the side walls of the channels are all soil and there are few boulders or rocks of any kind in the bottoms.

The design of the dams which have been constructed is the result of study of local conditions. They are of reinforced concrete and are open, box-like structures, the sides of which are thin panels supported by cut-off walls which penetrate 5 ft. into the solid side walls of the channel. The excavations to receive these cut-off walls are made just wide enough to receive the concrete and so there is no back-filling and the chances of percolation around the cut-off walls are reduced to a minimum.

The water falls over a semi-circular spillway into a pool, or water cushion, formed by a baffle wall between the sides. In structures where we seek to raise the bed of the channel 25 ft. at once it is the practice to have the first water cushion 8 ft. deep and a second below 3 ft. deep. The result of placing one of these dams in a channel is the filling up of the channel above the dam with silt and, while this is taking place, a cutting out or lowering of the bed of the channel below. After the channel is filled up above and a sufficient grade established for the water to carry silt, the portion below will fill up again. The outlet must be so designed that the structure will not be endangered by this lowering of the channel.

40-Ton Dynamite Blast at Wisconsin Quarry

One of the largest quarry blasts ever made in this country was fired last August at the Dresser Junction, Wis., quarry of the Trap Rock Co., of Minneapolis, Minn. We are indebted to Road Products for the following particulars of this blast.

Preparations for the blast were made on the gopher-hole system or coyote-hole, as it is known in the far west. Six tunnels averaging about 70 ft. each were driven into the face of the ledge. The distances between the headings were as follows: Nos. 1 and 2, 70 ft.; Nos. 2 and 3, 100 ft.; Nos. 3 and 5, 85 ft.; Nos. 5 and 4, 90 ft.; Nos. 4 and 6, 70 ft.

The headings or tunnels were no larger than necessary for the work of excavating them. In few places were the tunnels big enough for a man to stand upright. They were designed to be driven into the face approximately on a level with the quarry floor and with only slope enough for proper drainage, but no particular care was considered necessary to make the alignment accurate.

Each tunnel was provided with two cross-cuts, one about 40 ft. from the face of the ledge and the second 30 ft. beyond the first. The length of each cross-cut was from 20 to 25 ft. from the junction with the main tunnel, the interior cross-cuts being somewhat (about 10 ft.) longer than the outside ones. The ends of the cross-cuts were enlarged to provide storage room for the powder.

For exploding the blast two independent electric circuits were provided. Tied into the No. 2 circuit and using the same caps was a Cordeau-Bickford fuse. It was designed to use the No. 1 circuit, and in case of failure the No. 2. The Cordeau-Bickford fuse insured against failure of both circuits and made practically certain the explosion of the whole charge in case of failure of any part of the circuit. The six tunnels were connected in series to a hand-operated battery exploder.

The wires were led out of the tunnels in conduits made of the boards from the dynamite boxes, which protected them from the moisture and the filling material. The ends of the wire circuits were carefully wrapped in tire tape after they had been completed. The circuits in each tunnel were not joined in series until the blast was to be made. Frequent electrical storms made it essential to provide every possible precaution against an accidental explosion.

The blast broke out about 250,000 cu. yds. of rock.

News Letter

St. Louis Items

Costello Bros. have three steam-shovel outfits working night and day stripping ore for the Aluminum Ores Co. at Beauxite, Ark.

McMurray Contracting Co. of Kansas City was awarded the contract for the deep foundations of the new Wabash R. R. bridge over Rouge River, Detroit, Mich. They are also going to do the concrete work on the L. J. Smith Const. Co.'s new job on the White River branch of the Missouri Pacific R. R.

F. A. Grant is receiving congratulations from his numerous friends. Grant got tired of being a bachelor and was married to Miss Emma Smith the other day.

The western approach of the highway bridge at St. Charles, owned by the St. Charles Bridge Co., will be rebuilt with concrete at a cost of $85,000. Work will begin in 30 days and the contract calls for completion by Nov. 15. The bridge will be closed to traffic at intervals during the construction period. The approach was not damaged when the bridge was destroyed by fire in 1917 and continued in use after the span had been rebuilt.

Jerry Connors came in from Ohio to take a look over the new Frisco work that is going to be let next week west of the city here. Jerry says he will finish his grading at Versailles, O., in about a month or six weeks. Received word the day he was here that he was awarded 21 miles of state road work near Joliet.

Mr. Terry of the Walsh Const. Co. spent a day with us. Took a look at the new Frisco work and will probably put in a bid on it that will land the work for his company.

Harrington Bros. are about ready to break into the contracting business again. Have been laying idle for over a year waiting for something good to turn up. They think things are about right now for them.

I. D. Lain is increasing forces on his brick paving job in Bloomington, Ill. Imported a car load of southern negroes last week and is going to follow up this shipment with others weekly.

The Good Road Construction Co., 1706 Arcade Bldg., has between 60 and 70 miles of state road work between Leachville and Blytheville, Ark., to sublet.

A. H. Webster has finished his fresno work at Amarillo, Tex. Is in the market for some similar work. Has 10 teams.

Contractors when in want of work or labor for their outfits write Koenig Labor Agency, 612 Walnut St., St. Louis, Mo., 503 Delaware St., Kansas City, Mo., or 509 S. 13th St., Omaha, Neb.

A. B. KOENIG.

Personals

Orlando K. Morgan has been appointed chief engineer of the Carolina, Clinchfield & Ohio R. R.

William H. Lord has been appointed chief engineer of construction for the Jacksonville Terminal Co., Jacksonville, Fla.

S. G. Hobert has resigned as consulting engineer of the General Fireproofing Co. and will open offices in Chicago for a general consulting engineering practice.

Albert Hill Fay has resigned from the U. S. Bureau of Mines after eight years in the government service as mining engineer and will engage in general practice as consulting mining engineer and petroleum geologist. He is temporarily located at the Cadillac Hotel, 509 South Boulder St., Tulsa, Okla.

E. S. Draper has been appointed principal assistant engineer of the Boston & Albany R. R., with office at South Station, Boston, vice L. G. Morphy, resigned. Mr. Draper will have charge of general and structural engineering and new construction. The office of the engineer of structures has been abolished.

Harry Symons, formerly of Two Harbors, Minn., who has been in the government service at Nikolsk, Siberia, will leave about June 1 for Peru, South America, where he will be engaged in the construction work of the government railroad which will run from Peru to Dutch Guiana.

H. H. Garrigues, at present engineer of maintenance of way, Southern Division of the Pennsylvania R. R., has been promoted to be superintendent of Delaware Division. Other promotions include: Franklin Duane, now division engineer of Baltimore Division, succeeds Mr. Garrigues as engineer of maintenance of way of Southern Division; W. F. Miller, at present division engineer of Williamsport Division, succeeds Mr. Duane as division engineer of Baltimore Division; N. D. Vernon, at present supervisor of Maryland Division, becomes division engineer of Williamsport Division in the place of Mr. Miller.

Industrial Notes

Effective May 21, Ransome concrete machinery in the Atlanta territory will be sold by W. F. Goodrich & Bro., with offices at 10½ Auburn Ave., Atlanta, Ga. W. F. Goodrich for several years has been connected with the Ransome line in this territory. He has recently severed his connection as president of the Piedmont Motor & Machinery Co. and together with his brother has gone in business for himself. James Goodrich, the other member of the firm, is an experienced engineer and will look after this side of the business. In addition to the Ransome line they will handle a general line of equipment, such as hoisting engines, crushers, forms, etc.

The Sullivan Machinery Co., Chicago, has had a 3-reel film made by the Rothacker Film Manufacturing Co., Chicago, showing how drills, coal cutters, quarrying machinery, air compressors and drill sharpener machines are made at the Claremont and Chicago plants of the company. This moving picture, "Building Mining and Quarrying Machinery at a Yankee Shop," was completed in time to do considerable work this spring in schools. This summer it will be loaned to engineering societies. Employers who have equipment for showing films may borrow it. The Sullivan picture has a traveling companion, "The Story of Coal," which is borrowed from the United States Bureau of Mines. This coal film, which was also made by Rothacker cameramen, is considered the finest coal mining picture ever made. It tells the complete romance of coal, from the sinking of the shaft to the final loading into the cars. The film includes a trip through a coal mine many hundred feet underground.

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Roads and Streets—1st Wednesday
(a) Roads
(b) Streets
(c) Street Cleaning
(d) Municipal Miscellanies
(e) Management and Office System

Waterworks and Hydraulics—2nd Wednesday
(a) Waterworks
(b) Sewers and Sanitation
(c) Irrigation and Drainage
(d) Power and Pumping
(e) Management and Office System

Railways and Excavation—3rd Wednesday
(a) Excavation
(b) Management and Office System
(c) Quarries and Pits
(d) Steam Railways, Construction and Maintenance
(e) Electric Railway Construction and Maintenance

Buildings and Structures—4th Wednesday
(a) Buildings
(b) Bridges
(c) Harbor Structures
(d) Miscellaneous Structures
(e) Properties of Materials
(f) Management and Office System

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Is Increased Currency the Cause or the Effect of High Prices?

In a letter that appears in this issue, Mr. D. W. Kimball raises two questions: (1) May not increased currency be the effect of high prices, rather than the converse? (2) If increase in the supply of a commodity makes it cheaper, why does an increase in gold make prices lower?

If all currency were gold, and if all commodities were exchanged in proportion to their respective labor costs of production, it would be apparent that if a means were invented whereby twice as many ounces of gold were produced per man-day, two ounces of gold would be exchanged for the same quantity of any other commodity that could formerly be bought for one ounce of gold. In other words, the prices of commodities would be doubled as expressed in terms of ounces of gold. This simple condition does not exist, yet the same result follows when the total volume of currency is doubled, namely, that prices are doubled.

Currency may be regarded as a commodity whose special use is to serve as a medium of exchange. In the case of paper currency, that is its only use; in the case of gold and silver other uses may exist. But when these other uses result in reducing the gold or silver in circulation, it is evident that we may still speak of what remains in circulation as having but one function to perform, namely, to act as a medium of exchange.

Let a given quantity of currency be in circulation in a community, with a given velocity of circulation or rate of money turnover, and let a given average unit price for all commodities be in existence. Now suddenly add 10 per cent to the volume of the currency, say by the discovery of a Klondike. Scarcely any currency remains long idle. But when currency is put into use it "creates a demand" for commodities. Of course the creation of this demand is a mental process, but no mental process can bring about physical changes except as it uses physical means. A tramp may have a great demand for a glass of beer, but unless he has the money to buy it that demand is likely to result in no transfer of beer to the tramp. (We speak in the present tense, but we refer to the past as to both beer and tramp.)

The miners of Klondike gold put it into circulation, and it adds proportionately to the existing total demand for commodities, which demand is measured by the total volume of currency multiplied by its rate of turnover. If 10 per cent is thus added to the total volume of currency, the total demand for commodities is increased 10 per cent, and average prices rise 10 per cent, for in no other way can the entire currency remain in circulation unless through a decrease in the rate of money turnover. But rate of money turnover is accelerated, rather than retarded, by the appearance of addi-

E. and C. Now $4 a Year

The greatly increased cost of all items entering into the production of Engineering and Contracting makes it necessary for us to increase the subscription price to $4 a year. The specialized monthly issues can be subscribed for, as heretofore, at $1 per year. We have realized for some time that we would have to increase our subscription price but have delayed taking the step in the hope that changing conditions would make such action unnecessary. We are now obliged, however, in view of the increased scale of costs in all branches of our business to definitely announce the advance in subscription price to $4.

tional currency. This springs from the fact that the possessors of the new currency begin to bid for commodities against the possessors of the old currency, and thus force up prices. But when prices begin to rise, manufacturers and merchants seek to stock up to forestall having to pay higher prices later on. This leads to a demand for loans, and a more rapid turnover of money.

An increase in currency is not the sole cause of an increase in demand for commodities. The recent war made it very clear that anticipated shortage of foodstuffs, etc., led to a bidding up of commodity prices in advance of any increment in our supply of currency. This demand increased the rate of money turnover, but the increase was intensified by the arrival of gold from Europe.

A common mistake in reasoning is to assume that a given class of energy cannot be both a cause and an effect of the same class of energy. Thus it would appear absurd to say that high prices can cause higher prices, and indeed one recent economic writer has called all such statements false, and self-evidently so. But were he asked whether fire could cause fire, he would be forced to admit that it not only could, but that in no other way does a conflagration spread. Similarly a wind may fan a small fire into a great blaze and the great blaze will then itself increase the wind.

In reasoning about mental phenomena it is particularly dangerous to assert that a given kind of thing must be either a cause or an effect, and not both. Inflow of gold from Europe was one of the causes of a rise in prices, but that very result itself undoubtedly led to an increase in the issuance of more paper money by our banks, and thus led to a forcing of prices still higher. Nor is this reasoning reduced to an absurdity by saying that it would necessarily result in an unending inflation of the currency, for these are not the sole causes at work.

The currency that was added to our circulation during the last five years came into the hands of employers in various ways. Some of it came as gold sent in partial payment of European purchases of war supplies. Some was printed by banks and loaned to manufacturers and merchants. But, regardless of its source, once new currency gets into circulation, it soon finds itself "turning over" at the same rate as the rest of the currency, and perhaps causing a higher rate of turnover for the entire volume of currency.

Mr. Kimball suggests that Mr. Gillette's commodity price formula of April 7 issue can be transposed so as to make it read

$$M = \frac{W \times P \times E}{K \times V}$$

to indicate that the quantity of money (M) is as an effect of the other factors, notably the average price of commodities (W). An equation may designate the relation between certain causes and effects, but the ability to change its members does not necessarily indicate the possibility of reversing the causes and effects. Thus an equation may be written to show the rate at which heat will flow from a body of high temperature to one of lower temperature. But any change in the arrangement of the factors in the equation cannot be interpreted as indicating a possible reversal of the heat flow.

Royal C. Meeker on High Prices

The article in our April 7 issue on the causes of high prices contained the first published proof that recent high prices have not been due, even to a small degree, to any falling off of production in America. We are glad to find that Royal C. Meeker, Commissioner of Labor statistics, has come to a similar conclusion. In press dispatches of May 20, Mr. Meeker is quoted as saying:

> Under-production is noticeable only in certain lines. Newspapers have been stressing the fact that labor is not producing so much as usual. That is wrong.
>
> Figures show that labor is not loafing on the job. Where labor is efficiently and intelligently used, it is producing the full quota. Other manufacturers can increase their output if they will use their labor correctly.

Mr. Meeker predicts still higher prices for farm products, stating that substantially lower prices of foods can not be looked for until about a year from next fall. He points out that food requires about 36 per cent of the average family income, and that clothing requires about 15 per cent. Hence the recent reductions in prices of clothing will not have a marked effect on living costs.

A Reprehensive Attempt to Make the Courts Subservient to the Popular Will

It is hard to believe that there exists a fair minded man who would not subscribe to the principle that a judge should not be affected favorably or unfavorably by his own decisions. Yet at the present moment the mayors of several cities are urging the abandonment of state commission regulation of public utility rates and the substitution of rate making by local commissions. One municipal executive, Mayor Hylan of New York, has gone so far as to urge New York congressmen at Washington to draft an amendment to the judiciary code so as to grant original jurisdiction to state courts, instead of the federal courts, in litigation involving the legality of rates of charge for service furnished by public utility companies. In supporting this amendment Mayor Hylan has said:

> The judges of the state courts are elected by the people. They serve for limited terms and are directly responsible to the people for enforcement of the state laws. The judges of the Federal courts are not elected by the people. They do not serve for limited terms, but are appointive officers with life tenure.

The inference is plain: Judges of state courts are likely to render decisions favorable to the public, regardless of the evidence, for if they do not they will lose their jobs; whereas federal judges are more apt to be impartial, because their tenure of office is for life.

For unblushing demagogism it would be hard to beat this suggestion of the mayor of New York. Usually such efforts to debase the judiciary are couched in sophisticated phrases than ring sweetly in the ear, but Mayor Hylan comes out boldly with the demand that the judges who are to try utility rate cases shall be intimidated into making decisions favorable to the public! Other demagogic mayors have asked for "home rule" in rate regulation, and have thus sought to conceal the vicious character of their plans by attaching to them a title that is at least respectable. Not so Mayor Hylan. He has no scruples whatsoever in asking congress to deny utility companies the right to seek protection from unbiased courts.

The outstanding defect of laws relative to rate regulation by state commissions is to be found in the neglect to provide protection of the commissioners against the wrath of citizens who object to a raise in the rates of charge for public utility service. Right now the Public Utilities Commission of New Jersey is fighting for its life against a governor who believes it will be popular to get rid of a commission that has raised street car fares.

We cannot believe that the majority of the public is unfair. Hence we believe that the public itself would support a plan to protect judges and commissions in the event of their rendering unpopular decisions. It is self-evident that increasing the price of any service or commodity can rarely be a popular act; hence that rate regulating bodies and courts must occasionally render unpopular decisions, if they are fair to the utility companies. Let such facts be put squarely before the American people, and the politicians of Mayor Hylan's stamp will surely receive "thumbs down" for all "home rule" plans that involve any debasement of our judicial bodies.

The Underpaid Postal Employes

The Literary Digest is calling upon its readers to write to their congressmen to urge an increase in the wages of postal employes. There is no doubt that Uncle Sam is underpaying not only his employes in the postoffice department but in all other departments. Yet the American Federation of Labor has been favoring the nationalization of railways and of coal mines. It would seem that with an underpaid navy, an underpaid army, and an underpaid postal force, the Federation of Labor might have some misgivings —as to the probable wages of a government operated railway organization; but such misgivings, if they exist, seem to have been quieted by the theory that Uncle Sam is a lenient employer, at least when he is not deeply in debt. Lenient he may be, but never liberal except when votes are needed. It is conceivable that if two million railway employes were on Uncle Sam's payroll, he would treat them more liberally than he has treated his other employes; but it is also conceivable that the twelve million farmers would have enough voting influence to restrain any tendency of Uncle Sam to be too liberal with the two million railway men. Indeed it is probable that within a few years after the railways have been nationalized (should that occur) laws will be enacted making railway employes as helpless as sailors, soldiers and postal employes now are. It is the essence of governmental methods to reduce employes to the status of bond servants that dare not rebel.

Apparently the Federation of Labor leaders are beginning to think twice about the "Plumb Plan," for they are not so vociferous in their praise of it now as they were a few months ago. The hillside that showed solid green at a distance, proves, upon closer approach, to be rather sparsely sprinkled with bunch grass.

Currency Expansion and High Prices

To the Editor: Your letter and pamphlet reprint of your article of April 7 relating to variations in the average prices of commodities, sent to the Grand Rapids Building Contractors' Association has been referred to the writer for analysis and report.

I have been interested in this subject for some time in a general way and also because my position is such that I continually receive requests from owners to advise them regarding the probable trend of building costs. As an engineer, I am particularly interested in the method by which you arrive at your conclusions and the form in which they are stated.

While a number of your statements are rather startling and contrary to general opinion, your line of reasoning seems to substantiate your conclusions, and evidently the point is that ordinarily individuals considering this proposition are thinking about some particular items in which they may be interested, instead of all commodities, about local conditions instead of nation-wide, and about short time variation instead of the "long swing" of prices, as Babson terms it.

There is one point that bothers me, and has for a long time, and it is one which I have never succeeded in having made clear to me. That is, how in a definite concrete way expansion of currency or "M" in your formula occurs and why it is the cause of higher prices. It has always impressed me as a result of high prices, in other words, your formula might be expressed as M equals $\dfrac{W \times P \times E}{K \times V}$

I can see that if the Government and other nations start to place large orders with us, and manufacturers begin to compete for labor and raw material, the prices of these commodities will increase, and accordingly either "M" or "V," or both, must increase, as the result. If we have to pay more money to our men, I can see that we need more currency (M), or else what we have must change hands more rapidly (V), but this means that demand increases prices, and increased prices necessitate an increase in currency.

It is frequently stated that an increase in gold production or more importation of gold causes currency expansion and decreases the purchasing power of the dollar. When I ask why that is, I am told that when we have more of a commodity it always becomes cheaper. But except as used for jewelry, and other mercantile purposes, it seems to me that gold is not a commodity, but a standard of measurement. It appears to me much the same as claiming that if a factory making two-foot rules should double its output there would be only six inches to the foot.

In short, I would like to understand how this expansion of currency begins, and how the extra money gets into the hands of employers, and thus encourages them to pay higher rates for labor and material. I do not consider myself competent to argue the point, but am frankly in search of information, or as the Japanese school boy expressed it, "I ask to know."

D. W. KIMBALL.

Grand Rapids, Mich.

[Mr. Kimball's questions are answered in the editorial, "Is Increased Currency the Cause or the Effect of High Price."—Editor.]

Meanings of "Efficiency"

To the Editor: Your recent article on the "Factors that Affect Average Prices" makes a very strong appeal to me. In my judgment your formula for the average index price marks a considerable advance in the present day thinking of political economists. This achievement will probably be better appreciated in the years to come than it is today; hence it may not be amiss to commend your efforts now.

There is a great deal of loose thinking and writing upon the subject of prices. Therefore, I wish that it might seem expedient to you to issue a reprint of this article, so that it might be circulated among the intelligent class other than engineers. Each member of Congress and of the various state legislatures should have a copy, as also should the editors of the leading papers.

I am taking the liberty of suggesting that a full page chart showing the six curves should be appended to your article. These curves should present the variations in your four fundamental factors from year to year as well as the computed index price and the actual index price. I believe such a chart would "take" more quickly with the general reader than the tables and detail charts.

There is one feature of your article that I am unable to reconcile with my own line of thinking. Unfortunately you have used the word efficiency where I think you should have used the term "output per capita." For example, you speak of the efficiency of the miners and then take as a measure of that efficiency the value of the annual, output divided by the number of miners. This value of annual output might also be divided by the number of dollars invested and the output per dollar thus obtained, or it might be divided by the number of tons of machinery and tools used and an output per ton derived; but these quotients would not measure the efficiency of the dollar nor of the ton of machinery, yet they are also factors in the production process. As I conceive it, the fundamental idea of efficiency is the ratio of output to input. The efficiency of any factor in a production process is measured by the ratio of the partial derivative to the complete derivative.

To obtain the efficiency of the miners as a class, they would be considered as one factor in producing the output. It would be necessary to give a small increment to that factor (while keeping the other factors constant) and to note the effect of such on the output. Then in turn give increments to the land factor, the capital factor, and to the administrative (these increments would have to be measured by a common unit—their money value) and note the corresponding effects. The total increment to the output would be the sum of four. The proportional part that any one factor had in producing the total increment would be the ratio of its own increment to output to the total increment. Such ratio measures the efficiency. This is a different quantity than output per capita, which latter depends upon the number of days worked per annum.

The measure of efficiency which I have been advocating for the past 15 years (ratio of partial differential to complete differential) is an abstract ratio in which the time element does not appear. Is this not an advantage? The efficiency of a steam engine or other prime mover is not stated in time units.

Am I right?

R. C. BARNETT,
Economic Engineer.

Kansas City, Mo.

[Efficiency is a term having several meanings. Engineers have long been accustomed to use it as indicated by Mr. Barnett, but prior to such use efficiency meant "the state of possessing skill in any art or profession." About 12 years ago the term began to be used to denote the percentage of output of a worker as expressed in terms of some standard output per unit of time. We see no objection to such a use of the term.—Editor.]

Increase in Wages in Southern Lumber Industry.—According to a summary recently compiled by the Southern Pine Association incrtase in wages in the woods department for January, 1920, over January, 1917, ranged from 72 to 147 per cent, the schedules of pay in January last ranging from 32½ cts. an hour for common labor to 93 cts. for foremen.

Design of Riveted Connections to Resist Moment

By W. M. WILSON and F. E. RICHART.

In general, riveted structures are designed upon the assumption that the connections are frictionless hinges. In some parts of a structure, however, it is necessary to design the connections so that they will be able to resist large moments. The resistance to wind pressure of the steel frames of office buildings is due entirely to the fact that the joints connecting the girders to the columns are able to resist moment. Moreover, a girder framed between two columns may have moments on the end connections due to vertical loads on the girder unless the connection is so designed that relative rotation between the girder and column can take place without producing stresses. The design of riveted connections to resist moment is, therefore, a daily task in many structural offices. In spite of this fact, however, the design of moment-resisting connections is seldom provided for in specifications, nor is the subject treated with frankness in our engineering literature. This, no doubt, is due to the fact that the mathematical analysis of the problem based upon unverified assumptions and to the fact that we possess very little experimental data relative to the behavior of riveted connections subjected to moments. The subject of the resistance of riveted connections to moments is one of the many subjects which should receive the attention of our scientific investigations.

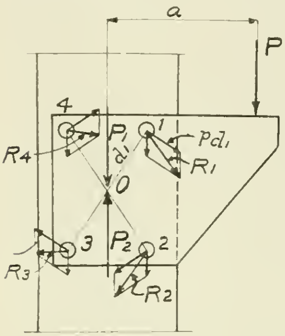

Fig. 1.

Before presenting the design of specific types of connections the writers will present the assumption as to stress distribution upon which the design of all types of moment-resisting connections is based. Fig. 1 represents a riveted joint carrying the single eccentric load P. At O, the center of gravity of all the rivets, introduce two equal and opposite forces, P_1 and P_2, each equal and parallel to P. The second system of forces is equivalent to the original system. The second system consists of a concentric force P_1 which produces equal vertical shears on all of the rivets, and a couple consisting of P and P_2 whose moment is Pa. It is assumed for purposes of design that this moment causes the plate to tend to rotate about O, that this tendency to rotate produces a shear upon each rivet, and, if the body to which the plate is riveted has the same rigidity in all directions, that the magnitude of the shear on a particular rivet due to the moment is proportional to the distance of that rivet from O and that the line of action of the shear on a particular rivet is normal to the line connecting the rivet with O.

If p represents the stress due to moment on a rivet at unit distance from O, then the shear on a rivet distance d_1 from O is pd_1, and the moment of this shear about O is pd_1^2. Likewise the moment of the shear on rivet 2 is pd_2^2, and similarly for the other rivets. Therefore for the joint in question $Pa = p[d_1^2 + d_2^2 + d_3^2 + d_4^2 + d_5^2 + d_6^2]$. From this equation p and also pd for each rivet can be determined if Pa is known. The concentric force P_1 produces a shear on each rivet equal in magnitude to P_1 divided by the number of rivets, and parallel in direction to P_1. Knowing the shear due to P_1 and the shear due to Pa, the resultant shear for each rivet can be determined by getting the vector sum of the two components. The resultant shears are represented in Fig. 1 by R_1, R_2, R_3, etc.

Having considered the general case of a riveted joint subjected to a moment we will now consider the design of specific types of connections.

Figure 2 represents a type of connection that is frequently used in office building construction to connect the girders to the columns in the bents containing wind bracing. The girder transmits to the column a shear and a moment. The shear will be represented by J and the moment by M. These stresses are transmitted through the gusset plate A. The joint can fail by the shearing of the rivets connecting the gusset plate to the column or by failure of the rivets connecting the girder to the gusset plate.

Consider first the stress upon the rivets connecting the gusset plate to the column. If the angles B and C were restrained so that they could not move horizontally the plate A would rotate about O and the stress on any particular rivet in either B or C would act in a direction normal to the line connecting the rivet to O and the magnitude of the stress on the rivet due to the moment would be proportional to the distance of the rivet from O. In this case, however, the angles B and C are not rigidly restrained against horizontal motion and therefore are unable to exert any material horizontal resistance. (The magnitude of this horizontal resistance is problematical.) It can be proven from geometry that for a given rotation of the plate A the vertical component of the motion of every point on the gage line B is the same. Considering stresses proportional to strains the vertical force on all rivets on the line B due to M will therefore be equal. The same statement can be made relative to the stresses on the gage line C. With O half way between gage lines B and C the sum of the downward forces on B equals the sum of upward forces on C. Letting the sum of the vertical forces on B be represented by P, then $Pa = M$ or $P = \frac{M}{a}$, and the stress per rivet due to M is $\frac{P}{n} = \frac{M}{an}$, where n is the number of rivets on each of the gage lines B and C. The shear J produces a downward force on all rivets equal to $\frac{J}{2n}$. The resultant stress on the rivets on gage line B is $\frac{J}{2n} + \frac{M}{an}$ vertically downward and the resultant stress upon the rivets on gage line C is $\frac{J}{2n} - \frac{M}{an}$.

The rivets in the plate K no doubt offer some resistance to the rotation of the plate A, but inasmuch as any horizontal stress transmitted by these rivets must be transmitted by the column angles acting in cross bending this resistance is not large.

Consider now the connection of the girder to the gusset plate. Inasmuch as the angles F and G are unable to offer much resistance to vertical shear, and inasmuch as the plate H is unable to offer much resistance to moment, it is customary to consider that the angles resist all of the moment and that the plate H resists all of the shear. The rivets in the plate H must therefore be designed to resist the shear J.

To determine the stress on the rivets in the angles D, E, F, and G, consider the moment M on the section xx. It produces the stress in the angles F and G. Representing the distance from the gravity line of G to the gravity line of F by d, the stress in the angle G, also in F, is $P = \frac{M}{d}$. The stress P is usually considered as equally distributed among the rivets in D and G.

Figure 3 represents a second type of connection that is used in wind bracing of office buildings. The design of the rivets in the angles C and D, and in the plate E are the same as for the joint represented by Fig. 2. Failure of the connection between the gusset plate and the column can occur in any one of three ways, by shearing the rivets on the gage lines B, by failure in tension of the rivets in the outstanding leg F, or by bending the outstanding leg F of the connection angles.

The shearing stresses on the rivets on the lines B can be determined as outlined in connection with Fig. 1.

The tension in any particular rivet in the outstanding leg F varies as the distance of the rivet from the center of rotation of the angle relative to the column. In the case of the plate of Fig. 1 rotation was about the center of gravity of the rivets, because all rivets are, or at least are assumed to be, equally rigid. In the case of the angle F of Fig. 3, rotation of the angle relative to the column is prevented by tension in the rivets at the top and by direct bearing of metal on metal at the bottom. Inasmuch as bearing of metal on metal is much more rigid than rivets in tension, the center of rotation of the angle F relative to the column is probably near the bottom of the angles. The distribution of the stress between the connecting angles and the column is probably somewhat as represented by (a) of Fig 3. The lower portion of the diagram represents the pressure of metal on metal near the lower end of the angles, whereas the upper triangle represents the unit tension on the rivets. With equal spacing of rivets the area of the upper triangle represents the total tension on the rivets and the area of the lower triangle represents the total pressure of the connection angles on the columns. These two resultant forces are equal and are represented by R. Although the location of O is unknown, the distance between the two R's is always $\frac{2}{3}l$. That is to say, $R = 1.5\frac{M}{l}$, no matter what the location of O is, so long as there is a triangular distribution of pressures. With a fixed value of R the maximum ordinate of the upper triangle depends upon the location of O. Because of a lack of experimental data locating O its position will have to be assumed. It is the opinion of the writers that O is near the lower end of the angles. With R known and the position of O assumed, the magnitude of the maximum tension per rivet can be computed. If the stress at unit distance is p, the stress at distance d is pd and $\Sigma pd = R$. The stress in the outer rivet should not exceed a safe value for rivets in tension.

In addition to the tension on the rivets due to the moment, the rivets in the outstanding leg F are also subjected to a direct shear due to J. In general, this shear J is quite small, considering the number of rivets so that the shear per rivet is small. Moreover, where the tension is a maximum, the elongation of the rivet reduces its rigidity to resist shear so that the direct shear per rivet is probably (?) less for the rivets subjected to a large tension than it is on the rivets subjected to a very small tension. (If this viewpoint is not accepted and we have no experimental data supporting it, the resultant stress on a rivet is the vector sum of the shear and the tension.) That is to say, with the moment as shown in Fig 3 and with the usual relations of J to M, the tension in the upper rivets, acting about a center near the lower end of the connection angle, can be considered as resisting the moment M, whereas the rivets in the lower end can be considered as resisting the direct shear J.

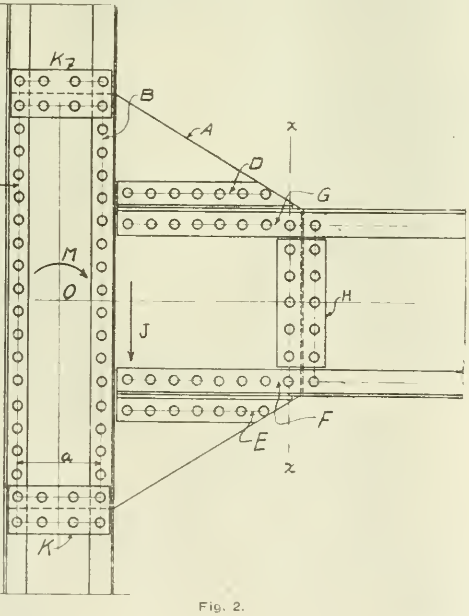

Fig. 2.

The connection of the gusset plate A to the column might fail, due to the failure of the angle itself. With the moment acting as shown in Fig. 3, the top of the connection angles tends to pull away from the column. A unit length of the angle near the top is acted upon by forces as shown in (a) of Fig. 4. The plate A tends to rotate and exerts a force at the top represented by f per unit length of angle. At the bottom end the angles kick in against the column. The outward motion at the top of the angle is resisted by the rigidity in cross bending of the outstanding legs of the angle acting as a cantilever. That is to say, the outstanding leg tends to bend as shown in (b) of Fig. 4. At the bottom the angle is prevented from kicking in by direct bearing of metal on metal. If the rigidities of the resistances to motion were the same at top and bottom the motion of the angle due to M would be a motion of rotation about the mid-length of the angles as a center. Because the rigidity of direct bearing of steel on steel is greater than the rigidity of a cantilever in cross bending, the center of rotation is probably near the lower end of the angle. Inasmuch as the tension in the rivets is the force which bends the angles, the diagram for f of Fig. 4 is probably similar to (a) of Fig. 3. The lower diagram represents the pressure of metal on metal near the lower end of the angles, whereas the upper triangle represents the outward pull on the angle at the upper end. The area of the upper triangle represents the total outward pull and the area of the lower triangle represents the total reaction at the bottom. The areas of the two triangles are equal and are represented by R. Although the location of O is unknown the distance between the two R's is always $\frac{2}{3}l$. That is to say, $R = 1.5\frac{M}{l}$ no matter what the location of O so long as there is a triangular distribution of pressures.

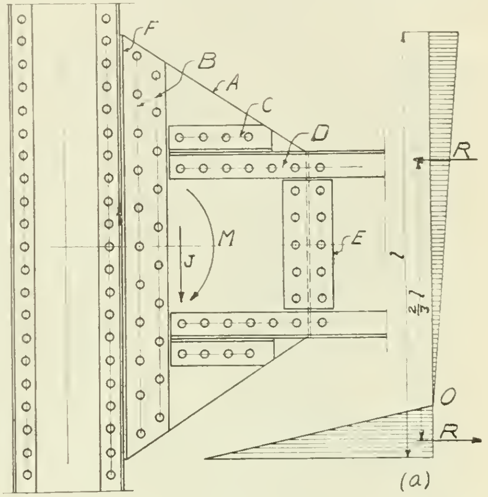

Fig. 3.

With a fixed value of R the maximum ordinate of the upper triangle depends upon the location of O. Because of a lack of experimental data locating O its position will have to be assumed. It is the opinion of the writers that O is near the lower end of the angles. With R known and the position of O assumed the magnitude of the greatest ordinate of the upper triangle can be determined. It represents the maximum value of f, force per unit length of angle, shown in (a) of Fig. 4.

With the maximum value of f known it remains to design the outstanding leg of the angle as a cantilever. The weakest section of the angle is in the plane xx. The strength of the angle depends upon the restraining action of the rivet head on the outstanding leg of the angle. Will the angle bend as shown in (b) or as shown in (c) of Fig. 4? If the angle bends as shown in (c) its strength will be just twice as great as if it bends as shown in (b). Personally, the writers believe that (b) represents more nearly what takes place. This being true, the moment on section xx for unit length of angle is one-half maximum value of f times a, where a is the distance from the center of gravity of the rivets to the middle of the leg of the angle.

If the gusset plate is large and thin the connection may fail by buckling the compression edge of the gusset plate. If the length of the unsupported edge of the plate exceeds 35 times its thickness ($\frac{l}{r}$ shall not exceed 120) the edge should be reinforced with angles.

This discussion brings out emphatically the need of experimental determination of the strength of connections to resist moment. There have been a few tests to determine the rigidity* of joints subjected to moments but nothing to determine the strength of such joints.

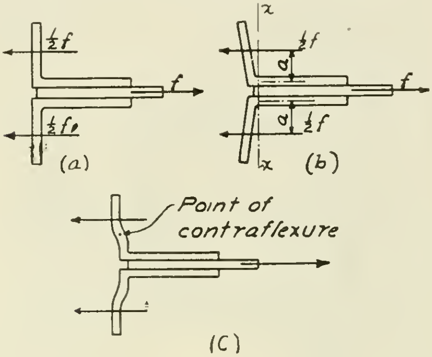

Fig. 4.

In determining the tension of the rivets in the outstanding leg F the computed stress depends upon the location of the center of rotation. If it is taken at the mid-length of the angles, as is done by many designers, the computed stress is twice as great as if it is taken at the bottom. It is the opinion of the writers that the center of rotation is near the bottom end of the angles, but the personal opinion of any individual is of little value unless it is supported by experimental data. Likewise in determining the bending in the outstanding leg F, the unit bending stress depends not only upon the location of the center of rotation but also upon the restraining effect of the rivet head. If the center of rotation is at the mid-length of the angles and if the angle bends as shown in (b) of Fig. 4, the unit bending stress is four times as great as when the center of rotation is at the lower end of the angles and when the angle bends as shown in (c) of Fig. 4. Too many of our complicated analyses entered into to effect a refinement of 10 per cent to 25 per cent are based upon unverified assumptions which, for aught we know, may introduce errors of 50 per cent to 100 per cent. Although we must not abate a particle in our efforts to refine our mathematical analyses, it is time that the structural engineers demand the experimental verification of the assumptions upon which the analyses are based.

Wages in Building Trades in New York City.—The Building Trades Employers' Association of New York City has granted a flat increase of $1 per day for all trades in the building field. The increase became effective May 1. The scale of wages per 8-hour day for certain trades is now as follows:

Carpenters	$ 9.00
Laborers, cement and concrete work	6.50
Hoisting Engineers	10.00
Housesmiths and bridgemen	9.00
Metallic lathers	9.00
Plasterers	9.50
Plasterers' laborers	7.00
Tile layers	9.00
Plumbers and gasfitters	9.00
Riggers and machinery movers	9.00

New System of Gunite Building Wall Construction

A method of house construction by means of the cement gun which minimizes the use of skilled workmen and the more costly building material has been developed by the Traylor-Dewey Contracting Co., Allentown, Pa.

The cellar walls and foundations are constructed of concrete by ordinary methods, and upon this foundation was first laid a 2 by 6 in. runner flatwise in such a position that the floor beams when placed will extend beyond the outside edge of this strip about 3 in.

The forms were made in units generally 3 ft. 8 in. in width of a height equal to the distance from the top of the foundation wall to bottom of the support for the second floor beams, in the case of first story, and equal to the distance from the second floor level to the under side of the roof beams in the case of the second story. The frame work of the forms consisted, except in the case of the top and bottom members, of 1 in. dressed lumber. Of the four uprights the two intermediates were 1 by 5 in. and the two outside are 1 by 4 in. The cross pieces in the case of intermediate were 1 by 4 in. and in the case of the top and bottom 2 by 4 in. From side to side of the framework were stretched and securely fastened by staples No. 10 wires spaced approximately 15 in. apart between cross timbers, as shown by Fig. 4.

Over the frame work and wires was placed and securely fastened a two-ply tar paper, shown in Figures 2, 3 and 4, making a unit of the forms against which the outside wall was shot or applied and to which the inner plastered walls were constructed.

The forms were then erected in place, the 2 by 4 bottom cross pieces extending under the end of the floor beams and butting against the 2 by 6 runner.

These forms were so placed as to leave a 4-in. space between each unit for the purpose of forming the studs, as shown in Figs. 1 and 2. Each unit was connected to its mate by a 1 by 6 board nailed to the 1 by 4 edge of each unit, thus providing the back form for the stud and at the same time making the inner face flush with the 1 by 5 in. uprights of each unit shown at (b) in Fig. 4.

Before attaching the last mentioned 1 by 6 strip there was fastened to it angle clips punched with ⅝ in. holes in the outstanding leg and spaced one near bottom and at intervals of 3 ft. upward and so arranged that when the 1 by 6 strips are nailed in place the clip will extend into the center of the stud.

The studs were reinforced in each case by two ½ in. steel bars spaced 3¼ in. centers and passing through the ⅝ in. holes in the clips. Each stud was anchored to the foundation by means of a short ¾ in. anchor bar previously cast in the concrete foundation and left to project into the stud about 6 in. Shown at (d) in Fig. 1.

In the case of the corners the inner surfaces of the studs were formed by the side of the adjoining form units as shown in Fig. 3. The angle clips were in this case attached to the side members of the form units and a bar in one set of clips omitted, leaving three bars in each corner stud.

After setting up the first floor form units and connecting them up as described, a 2 by 6 timber was placed edgewise on top of the 2 by 4 top members of the form units with its inner face flush with the inner edge of the 2 by 4's as shown at (f) in Figs. 2 and 3. This serves in part as a support for the floor beams of second story and in part as a backing against which to shoot the gunite.

The frame work for the interior partitions was then erected and the floor beams for the second story put in place in such a manner that their ends rest upon the 2 by 6 and extend 2 in. beyond its outer face, (g) Figs. 2 and 3. The space between the end of the floor beams were then filled in with 1 by 8 in. boards placed with outer faces flush with the 2 by 6 immediately below as shown at (h) in Fig. 2.

The space between the outer edge of the 2 by 6 and the face of the form units acts as a form for a reinforced gunite beam which in turn not only serves as a support for the floor beams, but, in connection with the gunite between ends of floor beams, acts as a firestop between the first and second stories.

The gunite beam is reinforced on its tension side by two ½ in. steel bars placed as shown at (j) in Fig. 5.

The second story form units were constructed and erected in the same manner as those of the first story with practically the same arrangements for roof supports as those described for the floor supports of the second story. In the case of the studs the same reinforcement is used, the upper bars being spliced to those below by means of wiring as shown at (k) in Fig. 5.

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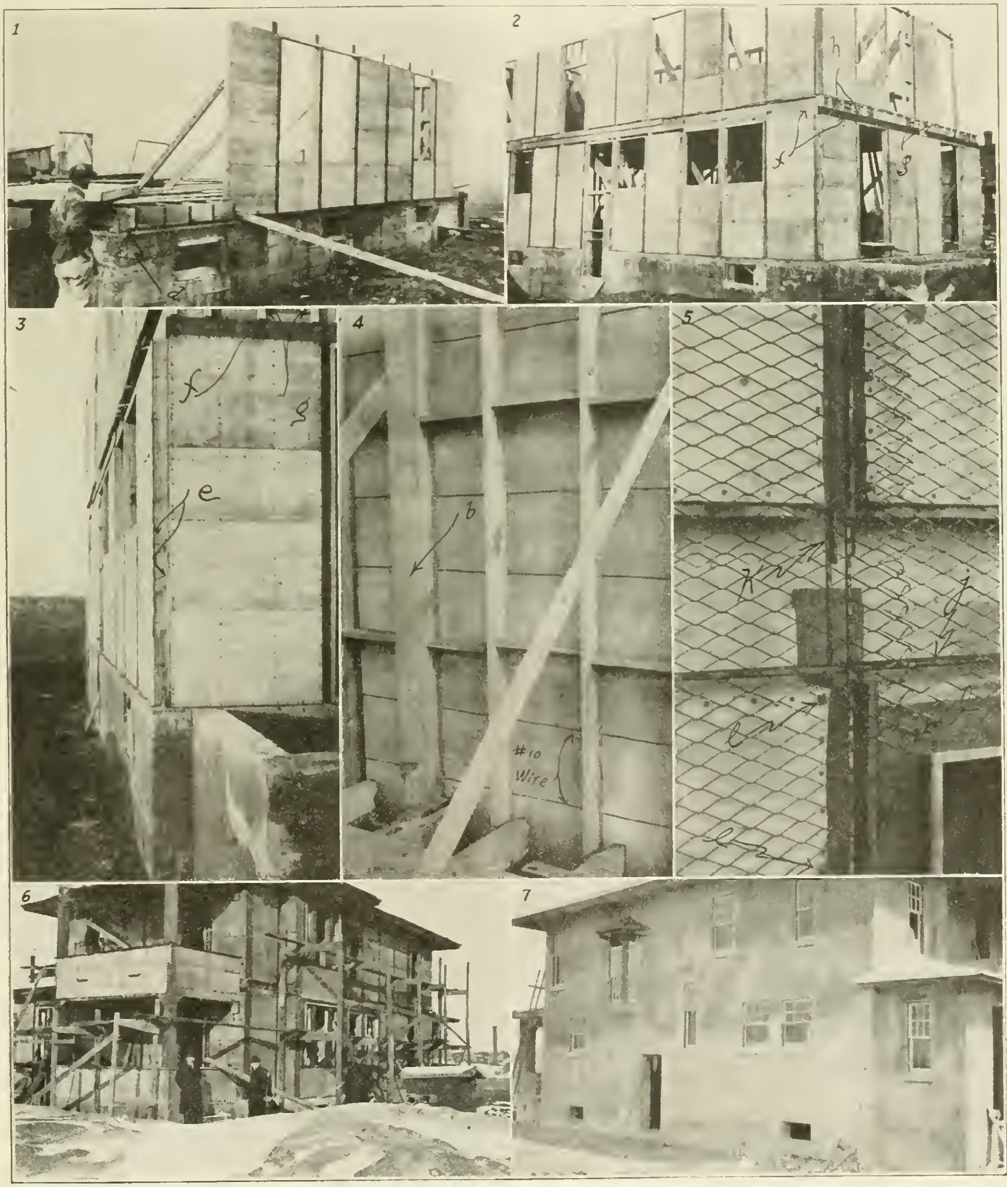
*Bulletin No. 104, Engineering Experiment Station, University of Illinois, Urbana, Illinois.



Various Stages of Gunite House Construction.

Over the forms when fully erected was placed 2 in. No. 13 steelcraft reinforcement, as shown in Figs. 5 and 6 inclusively and firmly attached to the forms by means of special mesh clamps (l) in Fig. 3, which not only secured the reinforcement but held it away from the tar paper surface about ½ in. In all cases where the reinforcement crossed studs it was firmly wired to the outside reinforcing bar.

Gunite composed of 1 part portland cement and 4 parts well graded crushed slag passing a screen of ⅜ in. mesh was then applied in the usual manner with the cement gun, working under an air pressure of from 30 to 40 lb. per square inch, to a finished thickness of 2 in., using such special wooden shooting strips as were necessary to insure square and true corner.

The gunite was applied in three coats, the first being about 1 in. in thickness or sufficient to embed the mesh reinforcement, and as this coat was applied the studs and beams were shot. When the first coat had set a second was applied approximately ¾ in. in thickness, after which the surface was gone over with a trowel or screed to remove any slight irregularities that existed. The final or flash coat was then applied to a thickness of ¼ in. or sufficient to complete wall to a total thickness of 2 in., leaving the surface the standard gunite finish.

Figure 7 shows the completed structure.

To the strip forming the back of the studs and to the inner edge of the uprights of the form units, which are flush with stud strips, metal lath will be attached and plaster applied by the ordinary hand methods, thus leaving a 5 in. air space between the inner and outer walls, with a gunite fire stop between floors.

New Industrial Developments Presented at Taylor Society Meeting

Important new developments in labor relations, management, production methods and selling were brought out at the meeting of the Taylor Society held in Rochester, N. Y., May 6, 7 and 8.

In a paper on "The Necessity of Planning in Administration," J. William Schulze of the J. William Schulze Co., New York, pointed out that planning is needed just as much for the president's job as for the machine operator's job. Too many factories, he declared, are carrying on production on the basis of orders coming in day by day. This results in peaks and slackness, over-production of some lines and shortages in others, price fluctuations, ill-will of the trade and similar troubles. Planning should be extended to future developments and to anticipation of profits. The three essential factors are: (1) Co-ordination between future plans and policies of business and current operation; (2) close interfunctional relationship between operating plans such as production and sales and capacity, and (3) profits and financial stability must be planned for, these being the two objectives of business.

An important phase of the planning of factory operations, "Balance of Work," was described by William D. Hemmerly, resident engineer, The Thompson & Lichtner Co., Boston and New York. By its means the management is enabled to ascertain accurately, constantly and instantly the condition of the plant insofar as work ahead is concerned. It keeps the departments balanced and co-ordinated instead of allowing one to run ahead of the other. It helps to keep operations as close to capacity as possible; permits better delivery promises and selling policies; employment according to needs, and timely provision of tools, etc. To carry out this function it is necessary to ascertain and maintain statistical information on capacity of all machines and work places, employes and tools.

How an industrial community has co-ordinated its facilities for serious study of problems and for co-operative action for progress was told by Henry T. Noyes, general manager, Art in Buttons, Inc., in an address on "Administration in Rochester." Although turning out a diversified line of products, including men's clothing and accessories, shoes, cameras, technical instruments and machine tools, all the prominent manufacturers of the city have organized to work out basic principles of all industry which would be of practical help to each of them. The purpose of the work is industrial progress, not as demonstrated in one "show plant," but progress in which all the industries of the community rise together. Ten years ago 15 executives representing the principal industries met together once a week and began the study of labor turnover, wage rates and similar questions. Finally in 1914, the Industrial Management Council of the Chamber of Commerce was organized and the industries assessed in proportion to the number of employes in order to provide the large sums needed for expert investigators and executives. The council is divided into groups including those for managers, superintendents, employment and service men, production men, cost accountants, and office managers. During the war all but industrial facilities of the city were co-ordinated so that there was no bidding by manufacturers for labor, and workers were "drafted" from the plants for war tasks

How manufacturers are losing production because of improper lighting was demonstrated by Ward Harrison, well-known illuminating engineer of Cleveland. In a paper on "The Necessity for Standards of the Relation Between Illumination and Output," he pointed out that tests in factories had shown that many manufacturers are saving $1 in improved lighting and wasting $10 in production. Increased production amounting to from 10 to 20 per cent have followed lighting betterments. He said that night shifts were inefficient, partly because of poor lighting. In plants averaging 100 sq. ft. of floor space per employe the cost of good artificial lighting per foot candle supplied is usually not over 0.1 per cent of employe's pay during the period.

"Can Industrial Democracy Be Efficient?" This question which is facing many industries in which workers are demanding greater participation, was answered by significant facts from the experience of the men's clothing industry in Rochester. This industry, which is the most highly organized in the country in its industrial relations, was described by Dr. Meyer Jacobstein, labor manager, Stein-Bloch Co. A strong organization of manufacturers, the Clothiers' Exchange, and a strong union of workers, the Amalgamated Clothing Workers of America, are co-operating for law and order, improved production methods and greater efficiency in the industry. After a year of operation the "Rochester Plan" shows higher standards of production, decreased labor turnover, operation uninterrupted by strikes and more satisfied workers. The industry employs 15,000 to 20,000 workers and where a year ago only 25 per cent belonged to the union, now 90 per cent are members. And yet, according to Dr. Jacobstein, wages are lower by 25 to 50 per cent than they would have been had there been no union, because the union has a stabilizing effect on wages which would rise owing to labor shortage. The plan consists of the representation of the employers by "Labor Managers" assisted by employment managers, production men and time-study men; and the representation of the workers by shop chairmen and a union manager. Disputes are settled by an arbitration court presided over by an impartial chairman whose salary is paid by both sides and whose decision is final. This industrial democracy plan is working effecetively because it is training leaders from the rank and file of workers; it has the full consent of the workers; it is educating the workers to the value of technical efficiency and scientific management, and it is putting the industry on a fact basis.

"The Worker's Reaction to Scientific Management" was the subject of an interesting address by Dr. William R Leiserson, chairman of the Labor Adjustment Board of the Rochester Clothing Industry and during the war connected with the Government's industrial activities. He declared that labor as such was not opposed to scientific management or to improved production, but that, expressing a basic human attitude, it is afraid of change. Before scientific management can be installed, he said, it is necessary to educate the workers and explain to them the whole truth. The purpose of management, he declared, is to get results, not to assert authority. The psychology of the workers must be studied, understood and taken into consideration. He said that the workers know what a fair day's work is and that standard should be a combination of their ideas and those of the management—both sides having experts to represent them. Many workers are not opposed to piecework if they have a strong union to protect them from rate-cutting. If the workers have a share in responsibility of distributing the total wage bill of the industry, as in Rochester, they see that wages are fair. He said more responsibility in management is necessary.

Examination for Senior Architect.—The U. S. Civil Service Commission will hold an open competitive examination for senior architects, applications for which must be filed with the commission before June 22. Two vacancies in the Interstate Commerce Commission under the act providing for the valuation of the property of common carriers, for duty in the Central District, each at $1,800 a year, and vacancies in positions requiring similar qualifications throughout the United States, at entrance salaries ranging from $1,800 to $2,700 a year, will be filled from this examination. Applicant must show (1) that he has had not less than four years of preliminary or apprenticeship training in architecture, or that he is a graduate in architecture from a recognized technical school, and (2) that, in addition, he has had not less than four years of actual responsible practical experience in architectural design and construction or supervision, some of which must have been acquired within two years prior to the date of this examination.

Studies in Co-operation and Drafting Room Management

To assist in the movement to create a better understanding between architects and their employes, Mr. George Bain Cummings, associate editor of the Journal of the American Institute of Architects, has undertaken an inquiry into existing policies of co-operation and methods of management. In the May Journal he gives some results of his investigation.

One of the most interesting co-operative plans is being worked out by a group of young men, each endeavoring to establish his own practice. Office space is rented from an older practitioner. Each man has his draughting and desk space, and shares in the use of the reception rooms, and in the services of stenographers, bookkeepers, office boys. When one man has little work of his own to keep him busy, he helps his busy neighbor who cannot handle alone all his own work. All are thus kept continuously employed, overhead expense is held down, each man shares in the experience and ability of the others, there is sufficient flexibility to care for a growing or fluctuating practice, and each man exhibits the apparent possession of a suite of offices much more impressive than he could hope to engage privately. Admission to such a group has to be on an elective basis, of course, because the benefits of the arrangement can be realized most profitably only when all the participants are perfectly congenial.

This plan suggests the possibility of amplification. It would seem profitable for the older practitioners to co-operate in the use of office space and assistance. The combination and concentration of facilities would assist in materially reducing overhead, in solving the serious problems of expansion and contraction as the practice fluctuates, and in keeping the draftsmen continuously employed, through a reservoir from which all the architects participating in the plan might draw in accordance with their needs. It is conceivable that substantial savings could be effected by placing contracts for blue-printing, stationery, supplies, and telephone service for the whole group.

Another interesting co-operative plan has been worked out to permit of very full participation by the employes in the work and interest of the firm. All the employes who demonstrate their ability and loyalty have a voice in the councils of the principals and heads, and problems of policy and procedure are settled by the vote of all. Matters of design are settled in the same spirit, after open discussion, criticism, and voting. A very large measure of self-government and individual responsibility is allowed the employes who respond splendidly, as would be expected. Any employe may have an interview with any principal or head whenever he wishes, and there is a sincere attempt on the part of all to understand the other man's point of view, and appreciate the good in him. Time is taken at more or less regular intervals to sit down "around the table" and discuss matters of all kinds that affect the profession or the larger life. It is a perfectly free and unrestrained forum, and all work is laid aside for it.

Another feature of this plan is the arrangement by which employes may introduce work into the office, and share in the profit from it. Every member of the organization is encouraged to secure work and bring it into the office. The work is handled like all other office jobs, the one introducing it working upon it in accordance with his ability, and sharing otherwise in the conduct of it. His name appears with the firm's on all instruments of service, and after the job account is closed he receives a percentage of the net profit, which is in addition to the salary he has been regularly paid while the work was in progress.

Profit sharing and bonus plans have been worked out in other instances. In the one case a distribution of a portion of the net profits, when above a certain sum, is made to employes on the basis of length of employment and salary earned. In the other case, if a job earns a profit over a certain sum, the job captain or man in charge receives a bonus; or, under a squad system, the members of the squad receive proportionate bonuses. Under such an arrangement a budget is sometimes set up at the beginning of the job, allowing so much cost for each stage of the work. Whatever the captain saves on that budget, is his bonus.

There are at least two objections to either plan mentioned in the above paragraph. One is that effort is stressed away from service and upon profit. Instead of making the service of architecture cost the public less, the tendency is to seek higher fees. Instead of making primary the quality of the service rendered, the tendency is to skimp on that service in order to secure the greater profit. And the second objection is that the average draftsman, who is trying to order his life in a sensible manner, would prefer a dependable and adequate income to a somewhat smaller regular salary and the speculative prospect of a bonus or an uncertain share in profits. Gambling is unscientific.

Compensation is probably the most usual bone of contention between architects and their men. Where the least trouble over this matter is found, it appears that draftsmen are paid just salaries—just relatively, as regards the ability of the members of the same organization, and as regards salaries in other organizations; and just absolutely, as regards the cost of living; that their deserts are carefully noted and their salaries adjusted accordingly without pressure from themselves; that a fair allowance is made for sickness, and for making up time lost for legitimate reasons; that the usual holidays are allowed without loss of pay; and that vacation in proportion to length of service during the year is allowed with full pay. It is pretty generally admitted by now that time clocks and systems of checking in and out defeat their own purpose, and that much more can be accomplished with a loyal, spirited organization coming and going according to the clock of its conscience, than with a herded group who check in and out and watch for a chance to "get even."

The question of time lost through jury duty is answered in some offices by making up to the man the difference between his salary and the amount received for the jury duty. It is recognized in this as in other similar matters that a man must occasionally take time away from his work to care for his personal affairs, and if his attitude and record are good, this time is allowed him without loss of pay.

An enlightened policy in laying off men is being adopted in many offices. Of course, any laying off is to be regretted as a loss in efficiency and a source of economic waste; and it is conceivable that under a broad plan of co-operation, this can be considerably reduced, if not wholly eliminated.

But where it still is necessary to dismiss a man he is given every opportunity to make a new connection without loss of income, no time limit being fixed at the end of which he must leave whether he has secured employment or not. In this same connection, let honor be given to those architects who have proved that they can never rise in the field of architecture, to apply their effort in the field in which they seem better fitted. The temptation is great to continue to profit by their steady work at low wages. Few resist the temptation. May their tribe increase!

Proposals regarding the training of draftsmen in offices are being revived. In most offices the men are allowed free access to the books and plates in the firm's library. But in very few is there any attempt made systematically to train and develop the draftsmen. In many instances there is a definite program of work and study laid down for an office boy, ending in promotion to the drafting room. But then his further development is left to himself, or to the friendly guidance of his older draftsmen associates.

In a few notable cases a sincere effort is made to give the draftsmen training in every phase of the work—design, drafting, detailing, engineering, specification writing, superintendence and accounting. This should be more generally done if only to justify our claim to be classified as "professional." A suggestion related to the above has proved of great mutual advantage where tried out; that is, to afford the draftsman opportunity to visit the work executed from his drawings. It is of the greatest educational value to the draftsman, and in his increased enthusiasm and more intelligent conception of the meaning of the lines he draws he is of greater value to his employer.

Little details of equipment and service which seem relatively important to the architect may seem quite large to the draftsman. They all contribute to his environment, they all influence the quality of his work. You will find them in the offices where the employes are contented, loyal and enthusiastic. Reference is made to such items of equipment as standard, individual drawing tables with private drawers; comfortable stools of the right height; a floor surface or covering that does not chill the feet; clothing lockers, clean toilet facilities, with hot water; individual towels and soap, pure, cold drinking water and individual cups; and to such items of service as the use of the telephone for personal matters; the use of stenographic and typewriting service, and postage and stationary at cost; facilities for receiving callers, mail and packages; financial accommodation in cashing checks, and extending loans where the case is worthy.

One office, appreciating a draftsman's interest in his finished drawing, presents him with a blue-print of every important or noteworthy drawing made by him. Another office has adopted a wise policy with regard to overtime. On the theory that everyone needs rest and recreation, no employe is asked or permitted to work longer than a total of 10 hours overtime in any one week. Most offices close entirely on Saturday during the warm months of the year, the employes making up the time in accordance with some mutually convenient arrangement.

Contract Provisions Proposed by Associated General Contractors

Sixteen provisions for the improvement of present contracts are recommended by the Committee on Coutracts of the Associated General Contractors of America in a report submitted recently. The committee has made a study of 113 different forms of contracts, and while it is not prepared at this time to submit a complete form of contract, it has approved certain provisions, which it recommends be included in every contract made by members of the association. The Committee on Contracts consists of J. W. Cowper, chairman, John W. Cowper Co., Buffalo; Arthur Bent, Bent Brothers, Los Angeles; M. L. Cunningham, Municipal Improvement Co., Oklahoma City; Avery Brundage, Chicago; V. T. Goggin, Fred T. Ley & Co., Inc., Springfield, Mass.; L. S. Oakes, Winston Brothers Co., Minneapolis; J. W. Rollins, Holbrook, Cabot & Rollins, Corp., New York City; E. Stanley Holland, Bates & Rogers Construction Co., Chicago.

The proposed contract provisions follow:

1. **Action on Bids.**—Bids should be submitted with the provision that they must be acted upon within a reasonable time.

2. **Freight Rate Changes.**—Bids should be submitted on the basis of existing freight rates, with the provision that in case a change in rates should occur between the time bids are received and the date fixed for the completion of the contract, the contract price should be increased or decreased accordingly.

3. **Wage Scale Changes.**—Bids should be stated and be submitted on existing wage rates, with the provision that the contract price shall be increased or decreased in accordance with any change in such rates before the date fixed for the completion of the contract.

4. **Material Price Changes.**—Bids should be submitted on the basis of existing prices for materials f.o.b. the producer's plant or distributor's yard, with the provision that the contract price shall be increased or decreased in accordance with any change in such price that takes place within the time allowed the contractor to purchase and fabricate his materials.

5. **Monthly Estimates.**—Monthly estimates should include materials delivered and suitably stored as well as materials incorporated in the work.

6. **Partial Payments.**—Certificates should be prepared and delivered to the contractor between the first and tenth day of each month, showing the proportionate part of the contract price earned during the preceding month. These certificates should be paid by the owner by the 10th day of the month. Interest on deferred payments should be paid the contractor at the prevailing rate.

7. **Contractor's Right to Stop Work.**—Under the following conditions the contractor should have the right to stop work or terminate the contract upon three days' written notice to the owner and the architect, and recover from the owner payment for all work executed and any loss sustained upon any plant or material and reasonable profit and damages.

(a) If the work should be stopped under an order of any court, or other public authority, for a period of three months, through no act or fault of the contractor or any one employed by him:

(b) If the architect or engineer should fail to issue the monthly certificate for payment in accordance with the terms of contract:

(c) If the owner should fail to pay the contractor, within seven days of its maturity and presentation, any sum certified by the architect or engineer or awarded by arbitration.

(d) If the owner does not permit the contractor to proceed with construction within a reasonable time after signing the contract.

8. **Retained Percentage.**—The retained percentage should be based on 100 per cent of the work performed and should never exceed 10 per cent. When the amount retained reaches a total sum, which shall be mutually agreed upon by the owner and the contractor, no further reduction from payments should be made.

9. **Surety Bond.**—Where a surety bond is given, it should be reduced at agreed intervals so as to cover thereafter only that portion of work then uncompleted.

10. **Penalty Clauses.**—Wherever any provision is incorporated in the contract for a penalty against the contractor (including liquidated damages), there should also be inserted a provision for a bonus of like amount.

11. **Acts of God or Public Enemy.**—The contractor should not be held liable for results arising from the acts of God or a public enemy.

12. **Time Allowed for Completion of Work.**—The time allowed for the completion of the work should be based on "weather working days" instead of on elapsed time, and, if necessary, allowance should be made for time spent in performing unproductive work made necessary by floods or other natural causes beyond the control of the contractor.

13. **Inspection.**—Where practicable, materials should be inspected at the source so that costly delay may not result from the rejection, at the site of the work, of materials furnished in good faith by the contractor.

14. **Force Account Work.**—Payment for force account work should be made on the basis of the total actual costs of the work, including the actual labor and material costs, rental on equipment, liability insurance, etc., plus a reasonable percentage to cover overhead and profit, total to be not less than 15 per cent.

15. **Change in Quantities.**—In case the actual quantities of any item in a unit price contract are less than the estimated quantities by more than a certain fixed per cent, the unit price paid the contractor for that item should be increased by an amount to be agreed upon. Similarly, a decrease in the unit prices should be made in case the quantities are increased over the estimate by more than a certain fixed per cent.

16. **Arbitration.**—In no case should the engineer or architect be made the final judge as to the interpretation of the drawings and specifications or the performance of the contract. All decisions and interpretations should be subject to prompt arbitration at the choice of either party to the dispute.

The "Ideal" Engineers' License Law.—The engineers' license laws of Iowa, Oregon and Florida most nearly fulfill the requirements of a desirable and ideal license law, according to a recent report of the legislative committee of the Twin City Chapter of the American Association of Engineers. The report names the important features of a license law to be:

Definition of professional engineering, land surveying, and architecture, and of professional engineers, land surveyors, and architects.

Qualification for registration and method of determining qualifications of applicants.

Reciprocity.

Application of law.

Revocation of license for cause.

Penalty for violation of act.

The committee recommends that in the license law proposed in Minnesota one of the members of the board of examiners shall be the dean of the engineering college in the University of Minnesota. A further recommendation is that members of the board should be appointed by the Governor from nominees submitted by the constituent engineering societies of the Joint Engineering Board of Minnesota.

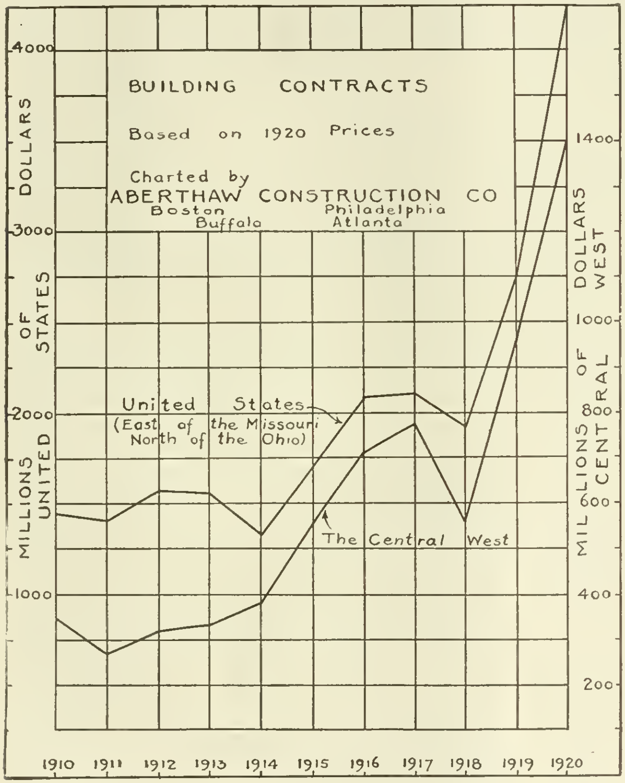
The committee recommends that no exemptions to the law be made, except for Government and military engineers on Government or military work, or those constructing buildings for themselves and for their own use at a cost of five thousand dollars or less.

Building Prospects for 1920

By MORTON G. TUTTLE,
Secretary, Aberthaw Construction Co., Boston, Mass.

For some time it has been possible to forecast from the returns of the first few months of the year the probable building volume for the entire year. Each spring this becomes an absorbing item among those interested in building, and many figures are prepared indicating the probable extent of construction work for the whole year.

It happens that the building figures for the first three months, during the years 1910 to 1919 inclusive, have amounted on the average to 18.26 per cent of the entire year's construction. If, therefore, we take this figure as about what may be expected from 1920, and consider that the total construction contracts reported by the F. W. Dodge Co. for the first three months of 1920 represents 18.26 per cent of what the entire year's work will bring forth, we may expect the reported figure of $780,408,000 to be expanded to $4,270,000,000 by Dec. 31.



Comparison of Building Contracts on Basis of 1920 Prices.

The magnitude of this total will be best appreciated when it is compared with building figures for preceding years. There have been only four years where the total has reached $1,000,000,000, and only one year where it has exceeded $1,700,000,000, the highest year completed being 1919, with $2,560,000,000. The other high spots of the past decade are as follows:

1918	$1,689,000,000
1917	1,618,000,000
1916	1,357,000,000
1915	940,000,000
1912	868,000,000

But it does not have to be emphasized that a million dollars of building today means far less than a million dollars of building meant 5 or 10 years ago. Relative unit cost figures have been compiled, showing about how the comparison runs per unit bulk of building. And, to get a fair comparison with the 1920 program, it will be necessary to increase all the other figures up to 1920 prices. This means that the 1919 figures must be increased by about 7 per cent, 1918 figures by about 13 per cent, 1917 figures by 30 per cent, 1916 figures by 54 per cent, and previous years' by 80 per cent. Figured on the new basis, so that the amounts shown represent building volume and not merely depreciated dollars, we have the following comparison of building construction in the area east of the Missouri and north of the Ohio:

1920	$4,270,000,000	estimated
1919	2,739,000,000	on 1920 prices
1918	1,909,000,000	on 1920 prices
1917	2,103,000,000	on 1920 prices
1916	2,090,000,000	on 1920 prices
1915	1,692,000,000	on 1920 prices
1912	1,562,000,000	on 1920 prices

It will be recognized that the figures immediately above have been corrected for all price differences, and that consequently they will represent the actual amount of building, all figured on the same unit costs which we are experiencing today.

The completion during 1920 of the stupendous building program outlined above will depend upon a number of factors. The press dispatches tell us that renewed strikes in Chicago have resulted in boosting the price of common building labor to $1 per hour, and skilled labor to $1.25 per hour. The same press dispatch tells us that, because of these exorbitant figures, fully 50 per cent of the projected building construction in that city has been abandoned. Similar conditions through the country would cut hundreds of millions of dollars from the building operations which we might otherwise safely expect.

Even as it is, owners are hesitating long before going to the high cost of building, unless the structure is so urgently needed that they find they can recoup its cost by profits within a short period. As prospective profits do not govern in residence construction, it is only natural that the building of dwellings should lag far behind that of industrial and commercial buildings, because the monetary return in the case of the residence is not so easily traceable, nor can the cost be repaid by business profits.

Thirty years ago the United States had about 110 families to every 100 residences. Three years ago the figure was about 115 families to every 100 residences; today it is more than 121. This points to heavy overcrowding in some sections, and to the substitution of apartments and two-family houses for the single houses of our forefathers. To get back to conditions of 1917 would require the construction in the United States of more than 1,000,000 residences, and this without making any provision for expanding population. This means that the 1,000,000 would be in addition to the normal annual requirements of nearly 400,000 per year to take care of increasing population.

Because of the conditions outlined above, much delay may be expected in making up this back work. On the other hand, large projects, such as factories and commercial houses will go ahead, regardless of conditions, so long as the increased cost of building can be passed eventually to the "ultimate consumer."

In the Great Central West District, from Ohio to Kansas and Minnesota, the record of the past 10 years shows that, on the average, 16.42 per cent of the entire year's building contracts are placed during the first three months. If that proportion is to hold good for 1920, then the $229,233,000 of contracts up to April 1 will be expanded to $1,396,000,000 before the end of December. The magnitude of this figure will be appreciated by two comparisons: with previous years' contracts in the entire area north of the Ohio River and east of the Missouri, including the heavy industrial region from Pennsylvania up through New England.

Compared with this year's prospective $1,396,000,000, the highest previous figure of $891,729,000 made in 1919 is far surpassed; and no other year ever provided over $600,000,000 of contracts. When we compare with the entire area, last year gave $2,560,000,000; 1918 and 1917, about $1,650,000,000 each; 1916 showed $1,357,000,000; and all previous years were below $950,000,000. These figures are all on the basis of "dollars reported," without reference to the great increase in cost of building since 1915, or depreciation of the value of the dollar, whichever way one may choose to consider it. Figuring the contracts of previous years on the basis of 1920 prices, we have the following comparison for the Central West:

1920	$1,396,000,000	estimated
1919	954,000,000	based on 1920 prices
1918	560,000,000	based on 1920 prices
1917	775,000,000	based on 1920 prices
1916	702,000,000	based on 1920 prices
1915	554,000,000	based on 1920 prices

No year previous to 1915 reported more than $215,000,000 of construction in this territory; and even when figured up to present prices, none of them provided more than $385,000,000. From these figures the immense building program now under way is at once apparent. It is sincerely to be hoped that it will not be cut in half by the grasping attitude of labor, as seems possible in the light of recent developments.

Changes in Union Wage Scales—1907 to 1919

Summarized figures concerning the changes in recent years in union wage scales, drawn from a report prepared by the Bureau of Labor Statistics, are given in a recent issue of Concrete. The statements are in the form of index numbers (percentages) in which the figures for each other year are compared with the figures for 1913; in other words, 1913 is made the base, or 100 per cent. The wage figures are as of May each year:

	Index number of		
Year.	Rates of wages per hour.	Full time hours per week.	Rates per full-time week.
1907	90	103	92
1908	91	102	93
1909	92	102	93
1910	94	101	95
1911	96	101	96
1912	98	100	98
1913	100	100	100
1914	102	100	102
1915	103	99	102
1916	107	99	106
1917	114	98	112
1918	133	97	130
1919	155	95	148

For all trades covered in the report taken collectively the average union rate of wages per hour in May, 1919, was 155 per cent of the average in May, 1913; that is, the average rate in 1919 was 55 per cent higher than in 1913. In 1907 the average hourly rate was but 90 per cent of what it was in 1913; thus the average hourly rate had increased between 1907 and 1919 in the ratio of 90 to 155, an increase of 65 points in the index, which number is 72 per cent of 90, making an increase of 72 per cent in the rate of wages per hour between 1907 and 1919.

The index numbers for full-time hours per week decreased gradually from 103 in 1907 to 95 in 1919. It should be borne in mind that these figures are percentages based on the year 1913, not actual hours. Index numbers for rates of wages per week increased from 92 in 1907 to 148 in 1919, or 61 per cent.

These index numbers are based on the union minimum rates as provided in agreements with employers. In some unions quite a percentage of members are actually paid, by individual arrangement, more than the union agreements specify. The average wage received by union men, therefore, to a greater or less extent, exceeds the prevailing union rate.

The business agents and secretaries furnishing the information as to wage rates to the Bureau agents frequently had only indefinite knowledge concerning the exact amount above the scale received by some members of the union.

Housing Committee Completes Organization.—The Senate committee appointed under the Calder resolution has completed its organization. The committee, of which Senator W. M. Calder of New York is chairman, will make a general investigation into building and housing conditions, with a view to seeing what steps the federal government can take to expedite building construction.

Speed of Metal Arc Welding

The speed of metal arc welding was discussed in a paper prepared by William Spraragen, department of electrical engineering, University of Washington, at a meeting of the American Welding Society, New York, April 22. The paper presents the results of extensive tests conducted for the welding committee of the Emergency Fleet Corporation during the war. It is summarized as follows by the Iron Age:

One of the most fundamental problems in the application of welding is to be able to compute the time of welding and to know upon what factors this time depends. The usual custom has been to express the time of arc welding in feet per hour for different thicknesses of material. When one attempts to use these figures as a basis for computing as to the cost of doing a given piece of work, he finds this information is too vague to be of value.

Obviously the number of feet that could be arc welded in an hour for a definite thickness of plate would depend very largely upon the type of joint that was involved. These differences could partly be avoided by expressing the data on the speed of arc welding in pounds of metal deposited per hour. It would then only be necessary to divide the pounds of metal that could be deposited per hour by the weight of added metal that would be occupied, say per foot of weld, in order to determine quite accurately the rate in feet per hour of welding the particular joint in question. In estimating this volume, it would be advisable to add 10 to 20 per cent to allow for the fact that the added material rises somewhat above the surface and is consequently of a somewhat larger cross section.

The average results of a vast amount of data show that an operator can deposit about 1.8 lb. of metal per hour in the shop; for outside work, an operator will average in general not more than 1.2 lb. per hour.

In welding up some 10 tons of ship plates for test purposes, it was found that on the average 70 per cent of the weight of the electrodes is deposited in the weld, 12 per cent is burned or evaporized and the remainder, 18 per cent, is wasted as short ends. The amount of power that would be required depends largely on the type of apparatus used, and the labor cost is a variable quantity depending on the local conditions.

Data obtained on the time, metal and current used with welds of different bevels, indicated that the advantages claimed by the American traditions (as compared with British practice which permits the use of smaller angles) for the larg opening are rather questionable if the time, electrode material and power saved by the smaller angle of bevel are also taken into account. Obviously one could have too small an opening in that the operator would not have sufficient room to operate his electrode. This point seems to have been reached for a total opening less than 60 degrees.

There is further basis for belief that a shoulder in place of the heretofore commonly used sharp bottom edge bevel will constitute a material gain not only in saving welding material, but also in the quality of the weld. The sharp bottom edge is always melted away during the welding process, leaving a larger opening than is necessary or even desirable.

Some excellent arc welding is being done with no preparation of the edges at all. The parts are lined up with a slight opening between them and two operators are employed, one located at each side of the weld

The recommended practice of current and size of metallic electrode in welding mild steel plate of different thicknesses is given as follows:

Electrode diam., in	Plate thickness, in.	Amperes.
1/16	up to 1/8	25-50
3/32	up to 1/4	50-90
1/8	3/16-1/2	75-160
5/32	3/16 up	125-200
3/16	1/2 up	175-250

In general the larger sizes of electrodes and currents would give a greater rate of deposit, but would require greater skill of the operator.

It was found that where an experienced operator is employed there is very little to choose between the merits of alternating current and direct current welding in so far as the speed is concerned.

Meeting of American Society for Testing Materials. The 23rd annual meeting of this Society will be held June 22-25 at Asbury Park, N. J., with headquarters at the New Monterey Hotel

The Future of the American Association of Engineers*

The reason for the existence of the American Association of Engineers is no longer open to debate. The answer is covered by the fact—10,000 new members in one year. The progress of the A. A. E. in the stream of professional advancement was blocked by the ice of conservatism. The ice has broken. The American Association of Engineers has reached a position of power and numerical strength where no combination can stop the progress in the accomplishment of its ideals. The Association seeks the co-operation and good will of all in the profession.

We are living in the days of readjustment. There is a reaction from the war period of self-sacrifice, generosity, and harmony. The restraint of the individual has been removed and the pent-up combative spirit of selfishness, greed and intolerance has broken into the flames of radicalism. Almost every separate trade, industry, business, or profession today is organized for its material ends. Those individuals or groups which are not so organized are at a merciless disadvantage in obtaining mere equity. They are but pedestrians in the road of reckless juggernauts.

Radical thought has not been confined to the trades. We have seen examples of scores of the most highly trained and specialized technical men carried off their feet in one evening's meeting to accept membership and dictation in the closest form of trade unionism. We are not here to discuss the merits or value of trade unionism to the trades; that is for them to decide. It is our province to consider dispassionately the relative advantages and disadvantages of trade union membership for men of the engineering profession or for those young men in the ranks who, by education and ambition, aim to become professional engineers.

Let us note the recorded statement of our Board of Directors:

> We believe in organized representation for the correction of wrong, the advancement of the profession, and service to the public, but are opposed to methods inconsistent with the dignity of the profession and which would lessen public confidence. The American Association of Engineers recognizing the many fundamental differences between the principles and objectives of the trade union and of an organization of professional men, expresses the opinion that an engineer cannot subscribe to the tenets of both.

The Association today has been the means of preventing the exodus of thousands into the alternative of trade unionism. The A. A. E. is conserving the unity and integrity of the profession. For this the thanks and respect of those most honored members of the old school is due to the American Association of Engineers.

In the year ahead, as in the past, the fundamentals for our activities are two-fold One, the aim to correct the errors and faults of the engineers themselves; the other, to correct or improve the external conditions and the public's relations toward the profession, which limit the opportunities and welfare of engineers and their usefulness to society.

We are beginning to be more candid with ourselves. We will approach perfection more quickly by recognizing our shortcomings. In our training as engineers we have become experts in the use of materials and their relative strengths. We have become masters in the determination of stresses and the utilization and knowledge of the laws of physics and, truly, that is fundamentally engineering. But efficiency is not limited to the acquirement of the best economy of materials; efficiency must include also the study of other relative values. As engineers, our training in the analysis of the strength and use of materials is exactly the training required for solving the problems in relative values, and those are the problems of the executive, the manager, and leader. Therefore let us expand the usefulness of our training to include the factors of relative values and cost. Let us study the human equation and develop the art of constructive imagination. Through efficient service to the public, our clients, our employer, the men we assist will measure our usefulness and our value and thus aid our material compensation and reward.

I am now, and all my life have been, an engineer, although I have held some official titles not designated as engineer. Therefore I am not guilty of heresy when I maintain that the training of an engineer should be a means and not necessarily an end in life's work.

In our relations to the public there are many important matters pending: Equitable compensation of engineers in municipal and railway service; the engineers' license law; a national department of public works; the enactment or modification of proper building laws and laws regarding reclamation, and public improvement; the question of professional ethics involved in outside work undertaken by public employes or officials. It should be our duty to aid in the solution of problems involving relations between the public and the various utility companies which are fundamentally engineering work. For example, the removal of onerous burdens on public utility companies which increase cost of operation without resulting in an improvement to the service. The public utilities companies may have sinned against the public in the past, now they have suffered the penalty and they are entitled to redemption.

There will arise other problems during the year, matters for prompt action for the welfare of the profession and its individuals. The greatest potential value of the American Association of Engineers is that they are organized and ready to act in any section of the country promptly and intelligently.

General policies, procedure, and initiative to a large degree must always devolve upon the membership and committees in the chapters. To carry out this work, to attend to the details, to act at the critical time, there is required the services of paid, full-time workers. We have a few of these local secretaries. They are busy men. There should be a representative of the A. A. E. with an open office in every geographical center They should be under the direct supervision of the national secretary with authority and duty to serve all the chapters within their district. Likewise, there will be required assistant secretaries to devote all of their time to the detailed work in specific lines of activity. Effective service for prompt detail work cannot be had without the man on full time and full pay.

The basic organization of the A. A. E. is correct. It has the two departments, the legislative and the executive. Our legislative department consists of the board of directors and the president, all elected for temporary tenure of office and without pay.The executive department includes the national secretary and his assistants in office and field; all are appointed for continuous service and paid.

We face the coming year with hope and confidence for the future of the A. A. E. We shall have our successes and our disappointments. I am a fatalist to the extent that I believe in the philosophy of "what ought to be will be." It is the philosophy of "Let us believe that right makes might." It is the philosophy of "Trust in God and keep your powder dry."

The following verse is very appropriate, I think:

I hate to be a kicker,
I generally stand for peace,
But the wheel that does the squeaking,
Is the wheel that gets the grease.

Let us not be dismayed but let us take advantage of that trait of American citizenship which, opposed from the outside, binds and unifies the associations of men in the fight for a common cause. In our work for the coming year let us meet this harried and petulant world with the attributes of engineering service she so sadly needs: sane, balanced judgment to govern decisive actions.

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*Inaugural address of President Le Roy K. Sherman, presented May 11 at the 6th annual convention of the Association.

Use of Hydrated Lime in Concrete

Conditions under which hydrated lime should be used in concrete construction in New York City are set forth in a rule adopted April 19 by the Board of Standards and Appeals of the city of New York. The conditions follow:

The hydrated lime shall conform with the standard specifications for this material which have been adopted by the American Society for Testing Materials.

The maximum amount of hydrated lime which may be used shall conform with the following table, all weights given being the amount of lime which may be incorporated for each 95-lb. bag of Portland cement.

1-1½-3 Mix, 4 lb. of hydrated lime per bag of cement.
1-2-4 Mix, 5 lb. of hydrated lime per bag of cement.
1-2½-5 Mix, 6 lb. of hydrated lime per bag of cement.

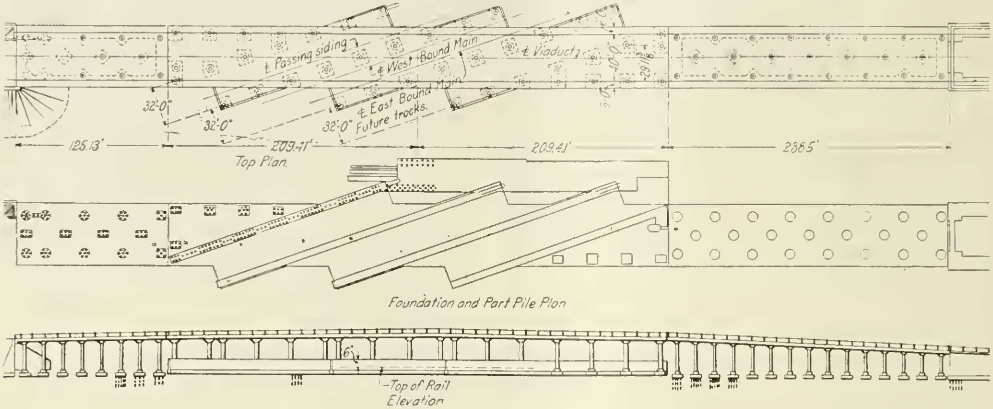
For hand mixed concrete, the hydrated lime and Portland cement shall be well mixed while dry.

Hydrated lime shall not be used in concrete which is to be deposited under water.

An Unusual Type of Flat Slab Construction

Four-way reinforced, flat slab construction was used recently in a viaduct with marked economy in construction. The unusual application of this type is employed in the separation of grades of the Newark Turnpike and the tracks of the Delaware, Lackawanna & Western R. R. at Sanfords Crossing, N. J. The work is described in the Railway Age, from which the matter following is taken.

Flat slab construction was selected only after exhaustive studies of the problem. This construction has the primary advantage of giving the most shallow floor system that could possibly be obtained. This was of particular advantage in this location as it gave the minimum length to the approaches which were to be built over perfectly flat ground. In addition the flat slab offered a flexibility not found in any other type of bridge design except the arch type, which could not advantageously be used here in that the floor slab could be warped slightly.



General Plan and Elevation of Viaduct.

As compared with all other forms of reinforced concrete construction the flat slab also offers the advantages of simplicity in the form work and in the arrangement of the reinforcing steel. In this type of construction there are two flat planes of the underside of the forms, the upper plane forming the underside of the slab and the lower plane around the columns forming the drop panel. The saving in materials in the flat slab type of construction is appreciable and increases with increased loading. In this structure, which had to be supported on piles, the use of this light type of construction resulted in a reduced cost of substructure and foundations.

By reason of its uniform cross-section and continuity of the reinforcement there is no type of reinforced concrete construction that is better able to resist shrinkage and thermal changes than the flat slab. Where expansion joints are necessary they are easily incorporated by forming a double row of columns, splitting the structure into independent sections with a clean-cut joint, the slab being cantilevered beyond the end columns to balance the negative movement.

The Newark Turnpike is one of the two thoroughfares connecting the highly developed manufacturing center of Newark, N. J., and the Metropolitan District of New York City. It, and the so-called Plank Road, the only other thoroughfare extending between Newark and New York, are numbered among the most important intersectional highways in this country.

The traffic over these two highways is extremely heavy and is moved almost exclusively by motor driven vehicles. For years the greater portion of it has moved over the Plank Road because of the poor condition of the Turnpike. That highway has now become inadequate to meet the demands of the rapidly increasing traffic and the Turnpike is being improved so that the congested conditions on the Plank Road may be relieved.

In connection with the highway improvement the roadway is being raised about 5 ft. above its former surface from a point in Harrison, N. J., to the Hackensack River bridge in Jersey City, a distance of 3¾ miles. The roadway is to be 40 ft. in width between curbs and a 10-in. Telford macadam road forms the base of the pavement. The base will serve as a temporary surface until the completion of the pavement which will consist of Belgian blocks laid on a 1-in. sand cushion over the macadam.

The Turnpike intersects the railroad at Sanfords Crossing, 3½ miles west of Hoboken, N. J. Through this district the highway and the railroad traverse the perfectly flat country known as the Newark Meadows and the highway is to be carried over the tracks by means of a viaduct and earth fills sustained by retaining walls.

Referring to the general layout it will be noted that the center line of the bridge forms the acute angle of crossing of 19 deg. 12 min. 20 sec with the line of the tracks. The viaduct is divided into three sections, a center section 418.82 ft. in length spanning six tracks, a north approach 125.13 ft. long and a south approach 238.5 ft. in length. Each section is separated from its adjacent section by an expansion joint formed by a 2-in. break in the floor slab located between a double row of columns.

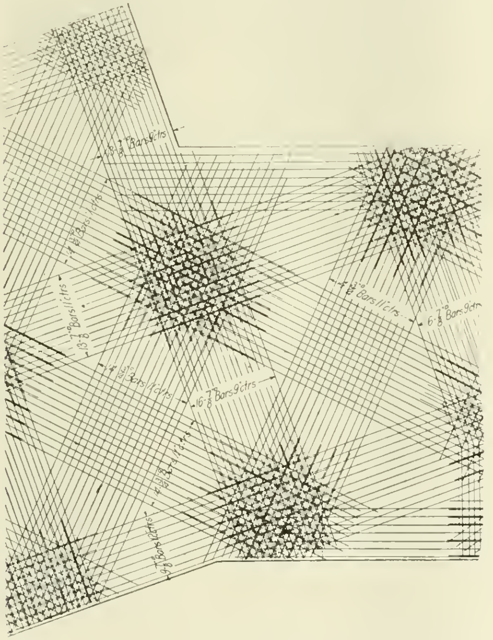
The south approach was stopped at a height where retaining walls and fill were found to be more economical. It was necessary to carry these walls for a length of 293 ft. to prevent the encroachment of the fill on adjoining property. The length of the north approach was fixed so that the approach fill fanning around the end corner would not encroach upon the future outside tracks.

The Morris and Essex branch of the Lackawanna carries a very heavy traffic, consisting largely of high speed suburban trains. At the point of intersection by the turnpike it at present includes an east and a westbound main track and a west-bound passing siding. In the plans for the improvement provision has been made for one additional westbound track and two future eastbound tracks. It will be noted that the tracks are arranged in pairs and the size of the slab panels of the center section over the tracks was determined in the one direction by placing the column lines on 32-ft. centers between each of the three pairs of tracks. In the other direction, lengthwise with the track, the spacing of the columns is 30 ft. 6⅝ in., forming an almost square panel. This spacing was determined by placing on the curb line of the viaduct the diagonally opposite end columns of the two rows adjacent to and parallel with the future outside tracks. The total distance between these two columns, one line projected on the other, is divided into 13 equal spaces of 30 ft. 6⅝ in.

In addition to the columns of the center section placed between the tracks, there is another row of four columns along the curb line which forms several irregularly shaped panels in order to carry out the triangular portion on each end of the center section, to a row of columns normal to the center line of the roadway in line with the last column of the outer row parallel with the tracks. With the exception of these few irregular panels all the panels of the center section are 30 ft. 6⅝ in. by 32 ft. This arrangement whereby the panels of the center section are placed normal to the track forms eight triangular portions of the slab which project beyond the sidewalk or balustrade line. These, however, considering the acute angle of crossing, are comparatively small, and little of the bridge floor is unused.

The columns of panels of the approach spans are placed in an unusual manner. Instead of being normal to the center line of the roadway, the panels are placed in a diagonal direction. This was done in order to bring the outside row of columns a sufficient distance from the face of the bridge so that the overhang formed thereby would balance the moments over the columns.

The center section over the tracks was designed to carry a uniform live load of 150 lb. per square foot, disregarding an impact factor and the approach panels, which are of greater size, are designed for 200 lb. live load or a maximum concentration around the columns of three 20-ton trucks. It was found, however, that the uniform live load gave the maximum moment. The total dead and live load in the design of the approach spans was 450 lb. per square foot which included the heavy Belgian block pavement. In computing the loads for the footings which are supported on wooden piles, four 20-ton trucks were concentrated around the columns in the natural line of travel to procure a maximum. In proportioning the overhang to balance the moment over the outer row of columns consideration was given also to an equal loading on all columns, so that each foot required the same number of piles loaded to 18 tons per pile for extreme maximum live load.

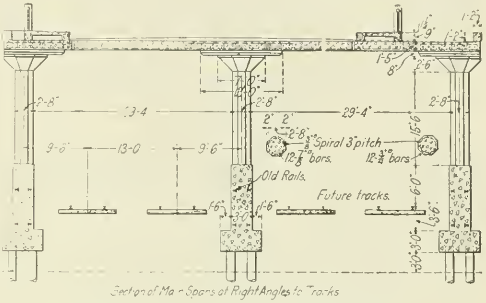


Arrangement of Reinforcement in Flat Slab Construction Over Track Openings.

The depth of the slab in the approach spans is 10½ in. increased to 15½ in. with the drop panel. The drop panel over the outer row of columns is carried for one-half its width along the edge of the slab to give the outer-diagonal band the proper strength. In other words, the slab for a 5 ft. 7in. strip along either edge has a depth of 15½ in. This outside diagonal band is further strengthened by the continuation of the bent-up bars of the direct bands (22 ft. 6 in. span) over the columns to the edge of the slab. In this manner the area of the cantilever action over the columns is increased, thereby effecting a greater stiffness in this long band by extending the point of contraflexure. The effect of approximately balancing the moments over the outer row of columns was a reduction in the amount of steel in the so-called interior panel.

Twenty-two feet is the minimum vertical clearance from the top of rail to the underside of the drop panel, the edge of which is practically the edge of equipment. The same clearance could safely have been made to the underside of the slab, but this additional clearance will in time be partially absorbed by raising the track due to re-ballasting.

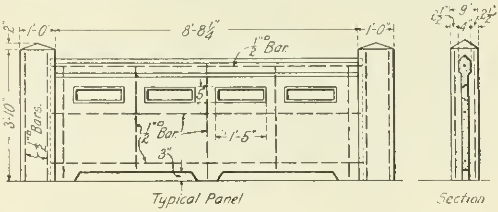
The columns between the tracks are protected to a considerable extent in case of a sideswipe from a derailment by placing them on a pier 3-ft. wide 6 ft. above the top of rail. The piers are reinforced by four lines of old rails. This high pier has another function in acting as a girder for the distribution of the loads on the piles which are spread out from column to column in narrow confines between the tracks, obviating the necessity of driving piles beneath the tracks.



Typical Section Through Main Spans.

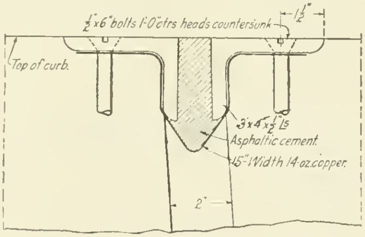
The panels of the concrete balustrade are to be 2 in. in thickness and are to be precast in a horizontal position during the construction of the viaduct. After they are thoroughly cured they are to be set in position and the posts will be cast in place around them. The precast panels will project into the posts 1½ in.

The wooden piles used in the work were reclaimed from repairs made to ferry boat racks on the water front of the Hoboken terminal. These piles, after 15 years of service, were broken down by impact of ferry boats and by weathering. The failure, however, was confined to the upper 18 ft. of the piles exposed above the water. The original length of piles was approximately 80 ft. so that by cutting off the defective ends after the piles were pulled a length in excess of the 35 to 50 ft. required for the viaduct construction remained in a perfect state of preservation.



Details of Concrete Railing.

With a limited space to carry on construction, the tower and chute method of depositing the concrete was chosen. Three towers, each 120 ft. in height, have been erected, one on the north side and two on the south side of the tracks. In laying out the plant due consideration was given to a minimum construction operation over the main line tracks.



Details of Expansion Joint in Roadway Slab.

The construction of this viaduct, which was begun late in 1919 and which is expected to be completed early in the summer of this year, involves 1,800 cu. yd. of concrete in the retaining walls, 2,010 cu. yd. in the column footings and protection piers, 2,530 cu. yd. in the columns, slab and parapet as well as 1,150 wood piles and 176 tons of reinforcing steel. The work is being carried on under the direction of Geo. J. Ray, Chief Engineer, and L. L. Tailyn, until recently Acting Chief Engineer of the Lackawanna, and M. H. Doughty, Division Engineer. A. H. Henckel, Resident Engineer, is in charge in the field, and A. B. Cohen, Concrete Engineer, is in charge of the design. H. F. Curtis, New York, is the contractor.

The Rod Method of Determining Unit Weight of Concrete Aggregate

Results of tests of the above method were given by the Committee on Concrete Aggregates of the American Concrete Institute in its report submitted at the last annual convention of the Institute. The following is abstracted from the report:

The new rod method is operated as follows:

Fill the measure one-third full of the aggregate, then, with a pointed iron of a prescribed size, jab or puddle the aggregate 25 times, distributing the strokes over the surface of the aggregate and avoiding penetrating through the layer of aggregate so as to hit the bottom of the measure. Then add another one-third to the contents of the measure and again jab with the iron rod 25 times, penetrating only the last layer of aggregate placed in the measure. Next, fill the measure to overflowing and repeat the jabbing, then strike off the surplus sand with the iron rod and weigh.

This method appears equally applicable to fine or coarse aggregate, or mixtures thereof, and its simplicity and convenience recommend it to consideration, since the results obtained are of a degree of concordance equal to that obtained with the best of the other methods considered in the 1917 report.

To investigate this method, it was desirable that the same aggregate be used that were used in the previous tests, so that results would be directly comparable without repetition of the earlier tests. Inquiry, however, developed the fact that only two of the laboratories co-operating in the 1917 series had retained their samples, so it was decided to have the new method investigated in only one laboratory using the same old samples, but having five different operators make five tests each with the same measures used in the previous tests, with the two grades of fine aggregate, each of them used in a dry and in a damp condition. These tests were, therefore, conducted in the laboratory of Westinghouse, Church, Kerr & Co., under the direction of the chairman of the sub-committee.

TABLE I—AVERAGE WEIGHTS OBTAINED BY ALL OPERATORS WITH ALL SIZES OF MEASURES.

Sand	Rod method. Lbs.
1. Coarse dry	107.5
2. Coarse wet	93.4
3. Difference	14.1
4. Fine dry	99.5
5. Fine wet	82.9
6. Difference	16.6
7. Dry	103.5
8. Wet	88.7
9. Difference	15.3
10. Average of all	95.8

TABLE II—AVERAGE OF DIFFERENCE BETWEEN HIGHEST AND LOWEST WEIGHTS OBTAINED BY ALL OPERATORS WITH ALL SIZES OF MEASURES

Sand.	Rod method. Lbs.
Coarse dry	3.8
Coarse wet	7.5
Fine dry	4.1
Fine wet	6.1
Dry (coarse and fine	4.1
Wet (coarse and fine)	6.8
Difference	2.7
Average of all	5.4

TABLE III—AVERAGE FOR ALL OPERATORS FOR ALL SIZES OF MEASURES, OF THE VARIATION FROM THE MEAN WEIGHT OF ALL OPERATORS.

Sand.	Rod method. Lbs
Coarse dry	.8
Coarse wet	1.6
Fine dry	.8
Fine wet	.9
Dry (coarse and fine	.8
Wet (coarse and fine	1.3
Difference	.5
Average of all	1.0

TABLE IV—EFFECT OF METHOD ON AVERAGE WEIGHT DIFFERENCE BETWEEN HIGHEST AND LOWEST WEIGHTS OBTAINED BY ALL OPERATORS FOR ALL RESULTS, AND AVERAGE VARIATION FROM MEAN WEIGHT.

Method	A	B	C	D	E	F	G	Cone	Rod
Average weight	88.4	98.8	103.2	104.3	98.0	83.9	87.2	116.4	95.8
Average maximum variation	7.0	7.0	7.9	5.3	6.5	6.2	5.8	4.1	5.4
Average variation	1.9	2.1	2.2	1.4	1.7	1.7	1.6	0.8	1.0

The six measures, described and illustrated in the 1917 Proceedings, were used. They were a 100 cc. cylindrical measure, a 1,000 cc. cylindical, a ¼ cu. ft. cylindrical, a ¼ cu. ft. cubical, a 1 cu. ft. cylindrical, and a 1 cu. ft. cubical measure. The rods used were ¼ in. in diameter by 18 ins. long for the 100 cc. and 1,000 cc. measure, ½ in. by 18 ins. (long for the quarter) for cubic foot measures, and ¾ in. by 18 in. for the cubic measures. The aggregates were a coarse siliceous Long Island sand and a fine siliceous New Jersey sand. These aggregates were used "room dry" and moistened to the extent of 3 per cent for the coarse sand and 5 per cent for the fine sand.

In order to make a comparison between the results obtained by this rod method and those reported on in 1917, a set of tables similar to those previously published are given herewith for the rod method.

By comparing this table with Table I on page 319 of the 1917 Proceedings, it will be noted that the rod method gives average weights about equal to those given by Methods B and E, or about midway between the right weights given by Methods A, F, and G, and the heavy weights given by Methods D and the cone method.

In Table II is shown the average difference between the highest and lowest weights obtained by all operators with all sizes of measures.

A comparison of this table with Table II on page 323 of the 1917 Proceedings shows that the rod method gives as little average difference between highest and lowest results as does Method D, and not appreciably more than the cone method. The rod method gives a small maximum difference as compared with other methods.

Taking up next the average variation from the mean, there is shown in Table III this average for all operators with all sizes of measures.

This table indicates, as will be shown by comparison with Table V of the previous reports, that the rod method gives more concordant results than any method used except the cone method, which is slightly better in this particular.

Coming now to a summary of the results obtained with all of the nine methods employed, there are shown in Table IV data which gives a very concise idea of the relative values of these methods.

From these data it is apparent that the rod method gives medium weights per unit volume, that it gives a low maximum variation, and a very low average variation. The only method offering lower maximum and average variations is the cone method, but as stated in the previous report, the unit weights obtained by the cone method are so high as to be of little value in practice and, therefore, not considered a desirable standard method for use in determining unit weights.

This committee has, in view of all the data available, voted in favor of the adoption of the rod method as the standard method for the determination of the unit weight of concrete aggregate, and proposes to prepare, during the coming year, standard specifications or the manipulation of the method for presentation at the next convention.

50 Reasons for a Federal Department of Public Works.—There are today in the National Government about 50 different departments or sub-departments which have charge of construction work throughout the United States for the National Government. No one of those departments takes a decided leadership. The result is that you are working under about 50 different sets of contracts and 50 different forms of regulations for control and inspection of the work. The only possible way of getting in the United States quickly a form of contract, procedure and inspection that will be reasonable and proper, is to get the control of all of the public works of the United States Government in one hand and under the direction of one person whom you can hold responsible for reasonable specifications, inspections, payments, etc.—From a statement of Frederick L. Cranford, Contractor, presented at annual meeting of the Associated General Contractors

Economical Speed in Building Construction

The conclusion of one of Aberthaw's Texts* reads as follows: "The judgment and experience of the estimator, in any given instance, must be relied upon to evaluate the influence of modifying elements of time, place and special circumstances." Mr. Angus B. MacMillan, Engineer of the Aberthaw Construction Co., in an article in the May Industrial Management, has elaborated on the time element and has put a rather abstruse subject into concrete terms. Abstracts from his able article follow:

Except where such speed is required as to necessitate purchasing materials from stock, at a price necessarily higher than where they may be obtained from the mill, the three main variables entering into the cost of building are the cost of the forms, the plant and the overhead expense. If the time of construction is to be shortened, the first two variables will be decreased, but the third will inevitably be increased. Due to the fact that the forms account for a much larger proportion of the total cost than do the other items, any material increases in the cost of forms will more than offset any possible gain from the other two items. When, however, account is taken of the interest on the money tied up in construction, without even considering the value accruing to the owner from his ability to occupy the building sooner, a nice balance may be struck. It is in selecting the point at which the gains from decreased cost of some of the items, and increased availability will overbalance the extra cost for forms, that judgment is shown to best advantage by the contractor.

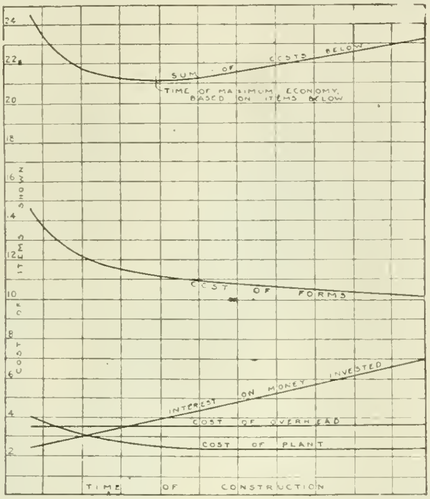


Fig. 1—Economical Time of Construction.

Effect of Slow Construction on Overhead and Cost of Forms.—For a typical building, figures have been prepared on the basis of which a diagram is presented (Fig. 1). These figures show the way in which the increasing cost of forms progresses as the building period is successively shortened, and the way in which at the same time the overhead costs decrease with the speed. Superimposed upon these curves is one which represents the accumulating interest on the money invested, which becomes heavy under the slow construction period. This compound cost, as shown by the resultant curve, shows that the minimum is reached at a point somewhere between the most rapid and the most leisurely construction. In other words, urgency for a building must be very great if the highest speed is to pay; while on the other hand, a very slow speed of construction is also more expensive than a moderately rapid progress.

Factors That Influence Cost.—When too large a number of men are placed on a job, not only do they get in each other's way and thus interfere with each other's individual efficiency, but also the problem of bossing a job is greatly complicated, because it is usually necessary to employ one gang boss or leader for each 10 or 12 men, and in some cases for even smaller gangs. The added cost due to this loss of efficiency is, of course, offset against the gain in time in delivery of the building. The added bosses form a definite addition to the overhead on the job, particularly where the overcrowding of men is considerable.

In the construction of a building, story by story, the time limit makes itself apparent primarily in the number of stories. There is no limit in the horizontal direction, except that imposed by the consideration of the number of men who can be effectively employed, and the necessity for an unfailing stream of materials as they are needed. But when it comes to adding stories to the building, the necessity of waiting after each story is poured until it is thoroughly set, before the next story can be touched, makes a very distinct limit and requires a careful schedule if satisfactory progress is to be made.

Speed Limited by Supply of Materials.—The limitation upon speed and efficiency based upon the ability to get materials as fast as they are wanted, and yet not fast enough to clog the works, is important; and there is another limitation based upon the character and capacity of the equipment used on the job. In two large textile mills now being erected by our company in Nashua, N. H., and Lowell, Mass., respectively, it happens that in each case the full capacity of the gravel banks in the neighborhood is being utilized. As gravel forms the largest bulk of materials entering the job, and as the principal cost of gravel lies in the cost of delivery from the bank to the job, it is evident that only an emergency requiring extraordinary speed in construction would make it feasible to go farther afield for other sources of supply, with the attendant increase in cost of delivery.

In one of these cases it happens that the layout of buildings in the neighborhood of this particular job is such that it was possible to locate mixers in one place only, and in this place two mixers have been put. Good practice requires that the mix be in the mixer one full minute. As it takes about 15 seconds to fill the mixer and about 30 seconds to empty it, this makes a net time of 1¾ minutes per batch. In practice, however, unavoidable minor delays easily increase this time to two minutes, so that the best work which can be expected from each mixer is 30 batches per hour.

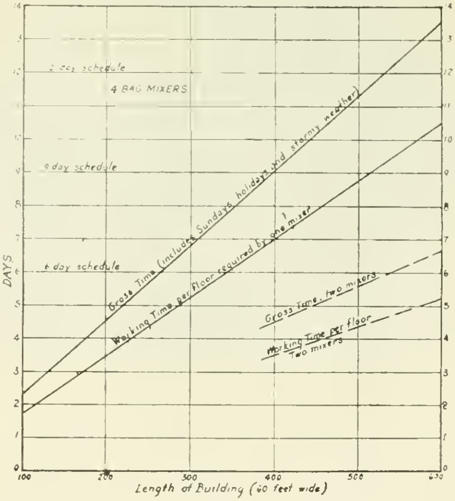


Fig. 2—Apportioning Mixers to the Job.

At 18 cu. ft. per batch this becomes 20 cu. yd. per hour per mixer, or 320 yd. per 8-hour day for the two machines. That these machines are actually being operated at practically their full limit of capacity is indicated by the fact that about 2,000 yd. of concrete are being poured per week on the job, with one hour of overtime per day, a part of which extra hour is always used in tuning up at starting and cleaning out at stopping.

Sequence of Crews.—On a small concrete job, where the carpenter crew is only one day ahead of the mixer crew and the steel men working their heads off in between, and then frequently having to work half the night to get ready for the next day's run, everybody is in everybody else's way and confusion is the result. An ideal schedule puts the carpenter crew two days ahead of the mixer crew and the steel crew half way between. On a large job this schedule is very easy to maintain, and gives excellent results. It enables the steel men to do their work within the allotted daily hours, avoids confusion and saves much interference and hard feeling.

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*Estimating Concrete Buildings, by Clayton W. Mayers, 1920.

In a building measuring 200 by 60 ft., which is a very common size for light manufacturing, we have 12,000 sq. ft. per floor. Including walls, columns and beams, this represents the pouring of about 15,000 cu. ft. or 555 yd. of concrete per floor. With a mixer furnishing 160 yd. per day, a floor may be poured completed in 3½ working days. If the schedule of forms provides for two floors at once, with a corresponding period approximating 9 days between floors, this means about 7 working days after deducting Sundays and the inevitable spells of weather when work simply cannot be prosecuted effectively. As the one mixer can handle the job in 3½ days, it follows that it is operating only half the working time. See Fig. 2. The mixer crew consequently has to be given other work over the balance of the time unless a smaller mixer is used, in which case the mixer crew is larger per unit of output than with a mixer of standard size, and consequently the unit cost is higher.

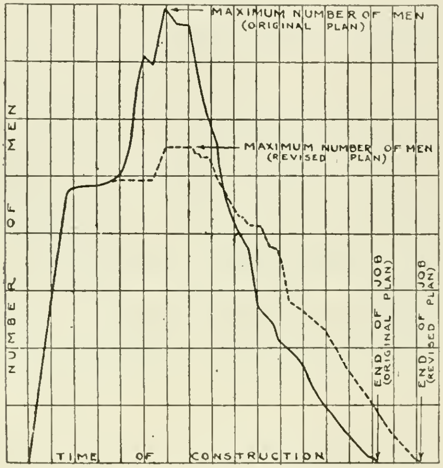


Fig. 3—Broadening the Labor Peak.

Number of Sets and Reuse of Forms. If the job permits the use of three sets of forms, and consequently reduces the average time per floor to six days, the mixer is kept busy nearly the entire time, and a much better mixer efficiency is obtained without using the men for other work. If, on the other hand, it is planned to use only enough forms for one floor, and to strip and reuse these forms, the schedule is opened up to 12 days per story, of which 9 or 9½ days are working days. Here the mixer, capable of doing its work in three and a half days, is working considerably less than in 40 per cent of the time.

A modification of the above reasoning may be found on large buildings, even though the period between floors be as great as 12 days. For instance, on a 5-story building, where the length of building was 500 ft. and the schedule was 12 days, with about 25 per cent more forms than were necessary for one floor only, the mixers were so adjusted to the job that they were kept continuously busy in furnishing concrete for bay after bay, until the end of the building was reached. By this time the 12 days' period at the other end had elapsed, and the second and subsequent floors could be poured immediately after the completion of the far end of each next lower floor.

Under conditions such as those obtaining in connection with the building of a plant for emergency war work, like this, or as in the case of the destroyer plant at Squantum, consideration of cost of forms does not enter. Here the requirement was to get the buildings out in the shortest possible time in which they could safely be constructed. Sufficient lumber to take care of all necessary simultaneous form work was on the job, and there was no hold-up in waiting beyond a reasonable time for the concrete to set.

Distribution of Man Days.—In one case in New York state, however, a different condition was met. Here the demand for the new building was not urgent. It was located in a small town where the capacity for caring for a large influx of workers was very meager. There were not sufficient boarding houses or hotel accommodations to handle more than a fraction of the number of men who would have been there for three or four weeks at the peak of the work. Rather than put the community to the inconvenience of arranging to accommodate these men for such a short period, a schedule was arranged which distributed the peak over a much longer interval and made use of many fewer men. The maximum number of men on the job was thus reduced by about 30 per cent. Figure 3 illustrates how this worked out with regard both to the length of the peak and the number of men.

It will be noted, of course, that the number of man-days was approximately the same in each case, but the distribution of these work-units was different. There was a large element of policy in the arrangement for it was recognized that the manufacturer whose operation was a large part of the life of the community would continue to operate there for many years, and could not afford to upset the town by overcrowding it with workers for the short period and then dropping them out completely.

From the above it will be evident that the mere question of dollars and cents is not always the answer, when economy is under consideration. The good will of the inhabitants of a small town may take precedence over need of manufacturing space to the extent of delaying a building for a month, as was the case above.

American Association of Engineers and the Organizing Conference

The American Association of Engineers has accepted the invitation of the Joint Conference Committee of the National Technical Societies to the conference to be held in Washington on June 3 and 4 to form a comprehensive organization. The following letter of acceptance was sent by C. E. Drayer, Secretary.

Your valued invitation of April 19 to the organizing conference of June 3 and 4, 1920, has been received by the American Association of Engineers.

The American Association of Engineers has for five years been engaged in the furtherance of the purposes announced in your kind invitation.

This association therefore accepts your invitation for the purpose outlined herein and will co-operate with your conference in any manner which will promote the welfare of the engineer and the objects of the American Association of Engineers.

In its co-operation with the organizing conference the American Association of Engineers must itself discharge the obligation which has been placed upon its 17,000 professional engineers.

This duty cannot be delegated to another organization, no matter how earnest its purposes may be.

In accordance with Section E, page 4, of the call, which requests an expression of the attitude of the association toward the proposed organization we may say:

1. Non-interference with the inter-relations with respect to technical matters and the maintenance of the autonomy, functions and operations of individual organizations.

We endorse this provision.

2. Local affiliation of existing groups of engineers in order to facilitate united action in local questions of public welfare and other matters of common interest.

This idea is approved.

3. National association of engineering organizations by means of a national council composed of representatives widely chosen by local affiliations or by organizations and by national organizations, meeting annually and acting through an executive board.

We are not in favor of this idea because in our opinion it would duplicate effort and add useless machinery, which would tend to restrict progress along welfare and non-technical lines. Our association is doing such work at the present time in an efficient manner and our growth proves that results are being obtained. This viewpoint is based on the result of our experience and consequently we do not believe that the organization proposed would be any improvement over existing machinery.

4. Financial support of such association by contributions from all participating organizations on a basis of membership.

In view of the above, little or no financial assistance from this association should be expected.

5. A form of organization which will permit expansion and development.

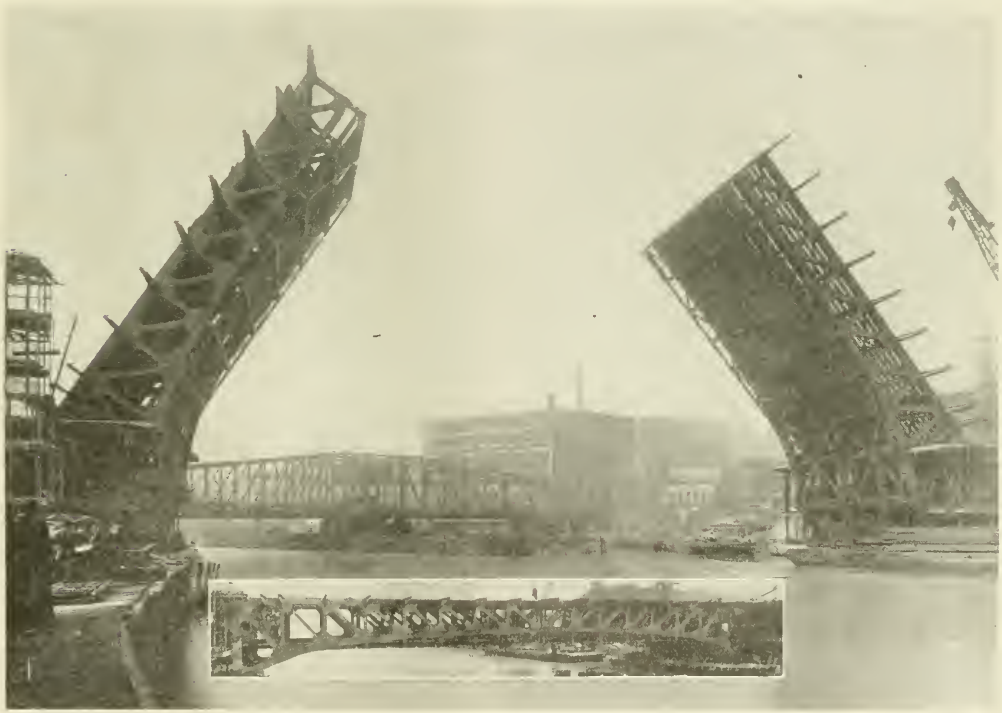
It is our opinion that the simpler the machinery for this end the better same will be adapted to expansion. Our delegates will be in a position to advise on this point.

All acts of our delegates would, of course, have to be approved by the association.

New Double Leaf, Double Deck Bascule Highway Bridge at Chicago

The second double deck bascule bridge in the United States was placed in service at Chicago on May 14. The other bridge of this type also is located in this city and carries Lake street and the elevated railway over the Chicago River. There also is a double deck bascule bridge at Fort William, Ont., designed by the Strauss Bascule Bridge Co. The two Chicago bridges, however, are of the trunnion type developed for city bridges by the Engineering Bureau of the Department of Public Works, under John Ericson as city engineer.

The new bridge crosses the Chicago River at Michigan avenue and is the main feature of the widening and extension project of that avenue. It has a span of 256 ft., and each leaf weights 3,350 tons. Each leaf has four electric motors of 100 hp., two of which are for reserve. The lower deck has two 18 ft. roadways and 6 ft. sidewalks, all between the trusses, and carries the truck and wagon traffic. The upper deck, which is reached by inclined viaduct approaches, carries automobiles. It has two 27 ft. roadways with 15 ft. sidewalks on cantilever brackets.



New Double Deck Bascule Bridge Over Chicago River at Michigan Ave., Chicago.

Plans for the bridge were prepared by the Bureau of Engineering under the direction of Hugh E. Young, engineer of bridge design; Thomas G. Pihfeldt, engineer of bridges; P. S. Combs, city engineer, and C. D. Hill, chief engineer of the Board of Local Improvements. Wm. A. Mulcahy was engineer in charge of construction and Chas. F. Harrington was engineer on electrical installation. The Great Lakes Dredge & Dock Co. was the contractor for the substructure and steel erection.

New York Engineers' License Law.—The bill for the licensing of professional engineers and land surveyors in New York State, passed by the Legislature April 24, was signed by the Governor, May 14.

Concrete As a Building Material

Although Edison's monolithic concrete houses are not yet numerous, yet concrete in its various forms in house and home construction is a recognized factor. The recent meeting of the National Conference Concrete House Construction held at Chicago* has done a great work in formulating and standardizing existing methods and stimulating further interest in concrete as a building material. Abstracts from the various papers read at the meeting are of interest, and point out the limitations as well as the good features of the material.

Warning and Encouragement in Use of Concrete for Housing Purposes.—Mr. Irvin K. Pond, the well known architect, in his paper, said:

The use of concrete in building operations has grown apace and enthusiasts and specialists have arisen to scatter their words and their works broadcast—sometimes, though not always, the words being more attractive than the works; sometimes the words and works alike bordering on the gramatically atrocious, as for instance when the beauties of cast-rock faced concrete blocks have been urged and the monstrosities themselves have made pitiable what otherwise might have been semi-respectable structures. "Semi," mind you, not "wholly" respectable, for the taste which could advocate and incorporate into its product such base imitations could not create or fashion a thoroughly respectable structure.

Some two years ago, while acting as chairman of a board to adjust and settle, perchance, jurisdictional differences between the carpenters, the architectural iron worker and the sheet metal workers of Chicago, I suggested facetiously that the fabricators of imitations should be penalized by giving over to the trades whose products were imitated the erection of all such imitations. Thus stone masons should erect all tin fabrications simulating stone cornices, architraves or entablatures, and do plastering where plaster simulated Caen-stone—one might put it "con" stone—on walls and in vaulted ceilings. My pleasantry was met with hearty and strenuous disapprobation; each trade wanted to tell its own little lie and to reap the benefits which each felt certain would accrue to it in a world so slightly endowed with the elements of sincerity or of good taste.

It behooves those who can impartially survey the entire field to offer both warning and encouragement: encouragement in its legitimate use, warning against its too free employment, especially where other materials may better serve the conditions. The economics of the general situation favor concrete, and through this factor alone there may arise a tendency toward its too general employment; toward its substituted for other materials which, though perhaps costing more in mere money, satisfy the senses and better fulfill geographic and climatic conditions.

The cheapness and ease of casting a flat slab of concrete has led certain enthusiasts to advocate the general adoption of a flat slab type of roof in any and all parts of the country (and ultimately of the world). It is advocated for a northern climate because it can very cheaply be made strong enough to hold a load of snow and ice. But that is not what a roof is for, it is to shed snow and ice. The flat slab roof is advocated for a southern climate because the overhang or shade is so cheaply procured. The shade is desired but not at the expense of ugliness which results from unembellished overhangs, and concrete embellishments are expensive.

The factors of ease and economy in manufacturing concrete slabs, whether to be applied vertically or horizontally, contribute to a "simplicity" which tends toward stupidity and to a barrenness which begets ugliness. Where the general form is stupid and ugly not much in the way of reclamation can be effected by proportioning of windows or application of superficial ornament. If the mass is interesting and appropriately conditioned, geographically and climatically, slight defects in details will not too seriously challenge the taste, but an ugly mass is fatal.

Because concrete has for so long a time been poured into moulds or forms and because of the coarseness of its ingredients, one of which was stone which could go through a 2-in ring, the earlier designers, and I fear there were architects among them, being dependent upon precedent, and knowing not where else to look, fell upon the crude Spanish detail and broad masses of the early Spanish Missions as representative of what best might be embalmed in concrete. And so Spanish missions distorted into bungalows and cottages and palaces spread like a rash over the face of the country. As technical and mechanical difficulties were overcome and processes refined the rash itched to take another form of disease and turned into a classic fever, with now and then a touch of Gothic "pains" were noted, particularly in the traceries on solids and in voids. The fever still burns, the pains still grip. Expensive forms are built up and destroyed to produce effects which already, ad infinitum, ad nauseam, have been better achieved in stone. However, this is not always to be.

Consequently another injunction, which I offer by way of advice, is to avoid wastage of forms; but even more to avoid the monotony which must follow the unrestrained employment of any "motif," ugly or charming. Introduce spice into life in the way of variety. The principle underlying this admonition is just as applicable to a mill town as it is to the most highly developed suburb. In point of fact, little or no distinction should be drawn between the mill town and the "swell" suburb. It should exist possibly only in the size of units; it should not exist in the expression of good taste and mental and bodily comfort. Perhaps I am getting ahead of the age and of the present topic. I hope not.

In spite of the manifold and varied means, methods, processes, applications, manipulations, textures, surfaces and colors appertaining to the use and employment of concrete as a medium of architectural expression and embodiment, I am not certain that I should advise its sole and unlimited agency in housing the activities of any one neighborhood or community. Indeed, I am quite certain that I should not so advise; and this, not altogether on the ground of a needed variety, but that there are other materials which transcend even concrete as a medium of certain desired expressions of the human spirit in the art of architecture. And I should desire to see no community curtailed of, or denied, the right and power to express the best that is in it in the materials best adapted to that expression. Thus marble, granite, iron, bronze, brick, slate, each one possesses inherent qualities or characteristics not translatable into concrete even through the agency of base and artificial imitation. In the matter of brick, for example, there is scale to the unit which relates the mass to human desire and experience in an intimacy possible with no other material, while in natural color and texture the range is boundless. But, even with all that, brick needs other materials in its neighborhood for contrast and variety purple, green or slate, soft white of stucco, weathered grey of timbers, with carvings and turnings, and craftsmanship which cannot be imparted by a mould, however exquisitely the surface be wrought by the modeler's hand.

Housing Conditions on Farms.—The Committee on Farm Housing gave as an indication of conditions more or less prevalent in every state, the following press item:

> "Ithaca, N. Y., Feb. 11.—The abandonment of farm life by men and boys during the last year for the city has left more than 24,000 habitable farm houses in the state vacant, according to estimates by Prof. G. F. Warren of Cornell university. His figures were based on a survey of New York farms which has just been completed by federal and state agricultural authorities.
>
> "Prof. Warren said that the figures explained to some extent the scarcity of houses in the cities. The exodus from the farms, he declared, has taken place despite the fact that farm wages will be higher by 14 per cent this year than last. He said the survey indicates that a single man this year will average $52.25 per month in addition to his board, while a married man will receive monthly wage of $68.50, in addition to a house for himself and family and some farm products instead of board."

The fact that housing conditions on many of the farms of the country are notoriously inadequate, undoubtedly is a strong contributory influence in promoting dissatisfaction among our agricultural population. During the war, building operations, except those relating to war industries, were restricted or greatly reduced. Although more than a year has past since the signing of the armistice, there has been no apparent relief from the situation. Unless conditions are remedied, this country will very soon find itself in the same difficult and involved situation which confronts agricultural Europe and which has assumed such proportions as to render it extremely doubtful if a desirable solution can be found without it being attended with grave consequences. All American industries are looking to agriculture to exert that ameliorating influence which might act as oil on troubled waters. No effort should be spared which in any way will contribute to the strength of this influence; agricultural content is essential to universal, industrial peace; good home life is the basis of agricultural contentment, and a good home is essential for the enjoyment of good home life.

Specifications for Concrete Block and Tile.—Subcommittee A of the Committee on Concrete Block Houses furnished a much needed set of specifications for concrete block and tile. Their general adoption should remove much of the stigma now attached to concrete block houses. The thoroughness of these recommendations is well illustrated by paragraph 10, which follows:

> When the combined live and dead floor loads exceed sixty (60) lb. per sq. ft., the floor joists shall rest on a steel plate not less than three-eighths ($^3/_8$) of an inch thick and of a width one-half to one inch less than the wall thickness. In lieu of said steel plate the joists may rest on a solid block which may be three (3) of four (4) in. less in wall thickness than the building wall, except in instances where the wall is eight (8) in. thick, in which cases the solid block shall be the same thickness as the building wall.

Relation of Architects and Engineers to Design and Construction of Bridges.—The question whether an architect or an engineer should have charge of the design and construction of bridges and other important structures was brought to the attention of Engineering Council by the American Society of Civil Engineers and by the American Institute of Consulting Engineers. Each organization had adopted formal resolutions expressing its belief that engineers should have charge of design and construction of bridges and other structures in which engineering elements predominated. Occasion for these resolutions was given by the engagement not many months ago of architects to have charge of the design and construction of certain conspicuous bridges in Pennsylvania. This perplexing problem has been considered by the joint committee of Engineering Council and the American Institute of Architects. After a full and frank discussion of the points at issue, the committee, composed of three engineers and three architects, all of whom were present, unanimously concluded that the special conditions surrounding each case should determine whether an architect or an engineer should be selected to have charge.

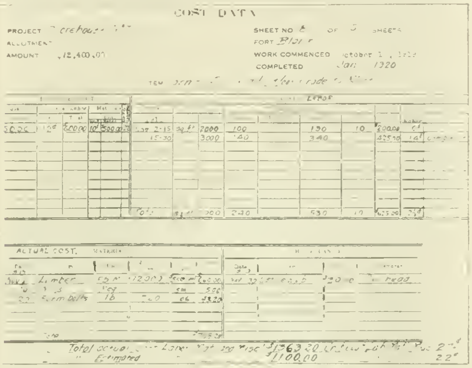
Flexible Cost Data Forms

By ARTHUR C. SWIFT.

A cost-keeping system, the chief characteristics of which are simplicity and flexibility, is outlined below, in connection with the use of form illustrated. This system was devised by the writer for use in cost keeping on the construction of small miscellaneous concrete structures and general construction work of the U. S. Engineer Department (2nd N. Y. District, Military Construction Division.)

The method of cost keeping by means of the sheets is as follows:

The various operations involved in the construction of a particular job are classified and entered under the heading, "Item," one (or more) sheets being used for each operation. For example, in the construction of a reinforced concrete storehouse the division of the work into operations for listing under the headings, "Items" and "Unit" of the cost data sheets would be approximately as follows, subject to as much variation in the divisions of the work under "Items" as individual requirements may describe:



COST DATA

PROJECT Storehouse

ALLOTMENT

AMOUNT $12,400.00

SHEET NO 6 OF 5 SHEETS

FORT Blair

WORK COMMENCED October 1, 1919

COMPLETED Jan. 1920

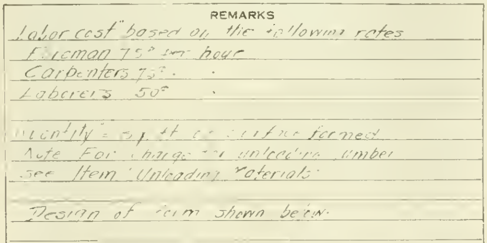
ITEM [illegible]

ACTUAL COST.

Total actual cost Labor, Mat. and Misc. $1363.20 [illegible] 22

" Estimated $1100.00 22¢

Front of Cost Data Sheet: Actual Size, 10 2 in. x 8 in.



REMARKS

Labor cost based on the following rates

Foreman 75¢ per hour

Carpenters 75¢ "

Laborers 50¢ "

Quantity = sq. ft. of surface formed

Note For charge for unloading lumber

see Item "Unloading Materials"

Design of form shown below

7/8" No. pine sheathing
6×6 walk
3/4" bolt
@3'0" ctrs
2'0"

NOTE- Include under remarks factors determining cost, such as plant, field conditions, etc

Back of Cost Data Sheet.

- Item: Excavation, unit cubic yard.
- Item: Unloading materials—units various.
- Item: Plant (concrete).
- Item: Forms, footing—unit, square feet.
- Item: Forms, foundation wall—unit, square feet
- Item: Forms, side wall—unit, square feet.
- Item: Forms, roof—unit, square feet.
- Item: Forms, column—unit, square feet.
- Item: Reinforcement, placing and bending—lbs.
- Item: Concrete, mixing and placing, footings—unit, cu. yd
- Item: Concrete, mixing and placing, walls—unit, cu. yd.
- Item: Concrete, mixing and placing, roof—unit, cu. yd
- Item: Doors—unit number.
- Item: Windows—unit number.
- Item: Lighting installation.
- Item: Clearing and removing debris.
- Item: Miscellaneous.

A typical entry is illustrated on the form shown. Under "Remarks" on the reverse side of sheet should be noted the essential features of the plant or method employed; conditions affecting the work, etc. The "Periods" may be taken at convenient intervals (as when payrolls are computed), or at divisions in the processes of work under that heading.

The sheets for each job may be bound together and if the job is large a "summary sheet" may be introduced. The columns "Estimated Cost" are added in order to afford a ready comparison with the unit costs used in estimating.

Limitations for Spouting of Concrete

Many engineers view with a certain amount of disfavor the use of chutes for distributing concrete for two reasons: first, because of the excess of water necessary, thereby weakening the concrete; second, because of the separation of aggregates. The views of Leonard C. Wason, President of the Aberthaw Construction Co., therefore should be read with much interest by both contractors and engineers. The following is reprinted from an article by Mr. Wason, in a recent issue of Concrete:

The question of handling concrete through spouting, involves consideration of both cost of operation and quality of final product. It involves also questions of the support of the spouting, and in many cases requires a tower so high that it is difficult to provide adequate stiffness. Where all the conditions can be satisfactorily met, there is no good reason in most cases why spouting should not be used, provided the concrete so spouted is delivered into auxiliary hoppers, where it automatically undergoes further mixing before being wheeled into forms.

The Aberthaw Construction Co., however, does not consider it advisable to spout concrete directly into place except when it is for the purpose of placing heavy masses of concrete, such as a large engine foundation, a dam or the piers and abutments for a bridge. For general building construction, the spouting of concrete from the mixer to a point near the final location of the material is frequently a great help, but considerations of both quality and cost make it usually inexpedient to spout directly into the walls or floors.

On a new job of the Aberthaw Co. at Dan River, it was found advisable, because of certain local conditions, to place the mixing plant across the canal from the new building. This makes it necessary to carry the concrete in spouts across the canal to a hopper located conveniently for final distribution. The same sort of arrangement has frequently been made when it was necessary to carry concrete from its point of manufacture or mixing across either a street or a group of railroad tracks or a small stream, in order to place it where it is ultimately to rest. In each of these cases the tower is erected on one side of the obstacle and the concrete chutes are suspended from a cableway or other convenient supporting element far enough above the obstacle to clear all possible contingencies, and the concrete shot across to the auxiliary hopper on the far side.

One objection to sending concrete by chutes a long distance is the considerable height of the tower that is required in such a case. Ordinarily the slope or declivity of the chute will have to be about 30 ft. in every 100 ft. In some cases even this figure is exceeded, and the slope may reach as high as 40 ft. This means that the tower will have to be that much higher, for spouting concrete, than it would have to be for delivering it in the ordinary way by wheelbarrows or cars. Not only this, but several feet more have to be added to the tower, because of the height from which the cable support has to be swung. Altogether, a tower for sending concrete to a distance of 200 ft. through a chuting system would have to be perhaps 70 ft. higher than for delivering the same concrete by manual means.

The rigging of the cableway, where it is done by the regular concrete laborers on the job, does not offer many complications, so long as these men are under adequate supervision When, however, it is attempted to move this unit, so that the concrete may be delivered at a different point, the complications sometimes become considerable. It may even be necessary to dismantle the whole works and set them up again in a new position.

In some cases in city work, particularly where union labor happens to be entrenched, other complications have arisen. For instance, in one case the structural steel union claimed the work of rigging the concrete chutes. The members of this union were, of course, expert in their own particular work of joining together the structural steel members of a building or bridge. They were not, however, especially skilled in handling the concrete chuting plant which they undertook to put in place. As a result, their work did not compare favorably with that of the concrete laborers who had definite experience in that particular work; and as their unit price or wage was twice as great per man as the laborers, the labor cost of this particular job was also twice as great as previously.

Theoretically, concrete should have about 6 per cent of its entire weight in the form of water. This is the amount chemically necessary to obtain the reaction at the time the concrete sets. In practice, however, concrete flows so poorly with only 6 per cent of its weight in water that a much larger proportion is commonly used. Frequently the percentage runs up to 10 per cent or more, in order to obtain a free-flowing mixture. As the pouring of concrete through chutes naturally requires more water than the handling in wheelbarrows or otherwise by hand, one would suppose that more water would be employed for the concrete which is to be spouted, as compared with that which is to be handled in the more usual manner. Ordinarily, however, this is not the case. The mixing is made in just about the same way as usual, and the excess water merely lubricates the mixture as it flows down the chute.

There is, however, a large amount of water used when chuting, because of the fact that, to start an easy flow, the chute itself must be thoroughly washed out with a hose, to get rid of particles of cement and sand which would otherwise stick permanently to it. Both these operations introduce appreciable quantities of water into the system, which have to be gotten rid of. They are not wanted in the forms or on top of the newly laid concrete, but must be discharged outside. Sometimes this is easy, but more often it requires a good deal of trouble and some expense to dispose of the surplus water.

The excess water used, in practically all concrete, is a decided detriment in so far as strength is concerned, for increasing the water content from 6 per cent to 10 per cent reduces the ultimate strength of the concrete by almost half. Inasmuch, however, as additional water is not ordinarily used for chuting as compared with the other practice, the strength, so far as water content is concerned, does not appear to be affected by the chuting process.

There is, however, a definite tendency for the mixed concrete to disintegrate to a certain extent in the chutes, the heavier pieces of the aggregate separating from the watery mortar of the cement, sand and water, instead of sticking together all in one mass, which is to become a homogeneous unit in the finished product. This is largely true when crushed stone is used for aggregates, because this will not flow so readily in the chutes as will the round pebbles of a good clear gravel. Consequently gravel is a better medium for chuting than crushed stone.

One method of concrete spouting which overcomes the disadvantages of chuting concrete directly into the forms consists in providing a small auxiliary hopper at the lower end of each section of spout. This is large enough, and subjects the concrete to enough of a fall so that the mixing is done over again at each junction point on the way down the chute. As the sections of the chute are usually about 20 ft. long, there would be half a dozen intermediate mixings in each 100 ft. or 150 ft. length of spout.

This method is frequently used in the effort to reduce the labor cost of transporting the concrete from the mixer to the form. It is not always successful in this direction, however, because the direct labor saved in placing the concrete is, in many cases, more than compensated for by the labor of handling the chutes, and the rental on the chutes themselves.

Fabricated Shop Contracts in March and April.—The records of the Bridge Builders' and Structural Society, as collected by its secretary, show that during the months of March, 1920, 83½ per cent, and April, 1920, 68 per cent of the entire capacity of the bridge and structural shops of the country was contracted for.

From the Note Book of an Engineer

By R. FLEMING,

American Bridge Co., New York City.

Early Building Codes.—The first building regulation of any American city, an "Ordinance of the Director and Council of New Netherlands regulating Buildings in the City of New Amsterdam. Passed 25 July 1647," begins:

> Whereas, We see and remark by experience the irregularity heretofore and still daily observed in building and erecting houses; in extending lots far beyond the survey line; in setting up hog pens and privies on the highways and streets; in neglecting and omitting duly to build on granted and conceded lots; the Honble Director General Petrus Stuyvesandt and the Honble Council in order to prevent the same in future, have resolved to appoint three surveyors, to-wit: . . .

We infer from this preamble that private trespassing upon public property was not unknown 275 years ago in what is now New York.

Another New Amsterdam ordinance, passed January 18, 1656, closes:

> Furthermore, the Director General and Council in order to prevent a too sudden conflagration do ordain that from now henceforth no houses shall be covered with straw or reed, nor any more chimneys be constructed of clapboards or wood.*

There was probably opposition to this regulation when it was promulgated just as there are objections to many of the very necessary requirements of building codes today.

The Color of Paint.—Many books have been written upon the technology of paint, but little is said in them about the color of paint. Almost a lone exception is the chapter, "The Light-Reflecting Values of White and Colored Paints" in Gardner's "Paint Technology and Tests." Experiments made by the author of the book showed the coefficients of reflection for different colors to be as follows:

Light cream	66	Medium terra-cotta	39
Light pink	60	Medium blue	32
Light yellow	58	Medium green	14
Light blue	55	Red	12
Light buff	52	Dark blue	12
Light green	42	Dark green	11
Light terra-cotta	41		

It is seen that the efficiency of both daylight and illuminants can be greatly increased by light-colored interiors.

The Industrial Commission of Wisconsin is giving considerable attention to industrial lighting. In their handbook on the subject they call attention not only to the marked economy of light-colored surroundings but also to the better hygienic conditions for the human eye.

Dark-colored paints not only absorb light rays, but heat rays as well. Gardner made tests to determine the most suitable finish for oil tanks. A series of small cylindrical tanks, the exterior surfaces of which were painted in various colors, were partly filled with a standard amount of benzine. Thermometers were placed through the pressure openings in the top, the tanks were individually placed in a cabinet containing an open front and subject to the rays of a powerful arc light for 15 minutes. The rise in temperature of the benzine was as follows:

White paint	22.5°	Light green	26.6
Light cream	23.0°	Red iron oxide	29.7°
Light pink	23.7°	Dark Prussian blue	36.7°
Light blue	24.3°	Dark chrome green	39.9°
Light gray	26.3°	Black	54.0°

Gardner thinks that when black or dark-colored paints are used on the large areas presented by metal oil tanks a rapid absorption of heat takes place and considerable losses by evaporation are apt to occur. For this reason, white or light-colored paints should be used for the priming coats. Paints presenting a high gloss are less absorptive of thermal rays than those presenting a matte surface. (Almost while writing these lines a number of Standard Oil Co. tanks are being repainted white.)

The Use of the Hyphen.—The correct use of the hyphen is puzzling to the engineer who has occasion to do technical writing of any kind. Professor Nolan, the editor-in-chief of the "Kidder" handbook, in a letter to the present writer throws light upon the subject. He says:

> In regard to compound words in which the hyphen is used, I have followed the system adopted and recommended by the Standard Dictionary. It is the only logical method that I know of. The method is perfectly consistent when understood. For example, we write "steel-contractor" because the expression is an inversion

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The originals of these documents are in the New York State Library, Albany. The translations are from O'Callaghan's "Laws and Ordinances of New Netherland, 1638-1674."

of speech, that is, it is a short way of saying "the contractor for the steel." Steel is a noun and not an adjective. We don't put hyphens between nouns and the adjectives which qualify them. If the contractor is made of steel instead of flesh and blood then we omit the hyphen.

Again we write, "dead load." "live load." and "wind-load." The words "dead" and "live" are adjectives; the word "wind" is a noun. The wind-load is caused by the wind, but the dead load is not caused by the dead.

Again a brick yard is a yard, perhaps paved with bricks; while a brick-yard is a place or a yard where bricks are made.

The garbage-man is the man who removes the garbage, while the snow man is a man which the children make out of snow. If the man who removes the garbage were made of garbage we would omit the hyphen.

What Is a Non-Binary Fraction?—In the 1919 edition of "Cambria Steel" are two pages with the heading, "Decimal Equivalents of Non-Binary Fractions." The question, "What is a non-binary fraction" having been raised the writer wrote to George E. Thackray, the Special Engineer of the Cambria Steel Co. and compiler of the handbook, for information and received from him the following lucid explanation:

> We have used the term "Non-binary Fractions," on pages 444 and 445 of "Cambria Steel" 1919 edition, to designate fractions other than those customarily used for expressing dimensions or measurements which have denominators of 2, 4, 8, 16, 32, 64, etc., expressing halves, quarters, sixteenths, etc.
>
> The word "binary" means pertaining to, characterized by, or made up of two, and the word "binary" is therefore applicable in designating fractions with denominators based upon two or any power thereof, as above indicated. You can find an example of the use of this word in Halsey's "Handbook for Machine Designers and Draftsmen" in the titles of pages 267, 468 and 481.
>
> The term "non-binary" is a designation for fractions other than those having denominators of two or powers thereof and these figures are useful in making calculations relating to angles, slopes, grades, etc., or in fact anything in which mathematical ratios involving such figures appear.
>
> You will further note that our table omits 3rds, 5ths, 6ths, 10ths, 20ths and 25ths, which are also non-binary fractions, but they are so easily determined by inspection that we did not print them, as we had to condense the space in which the table appeared."

A Preacher on City Planning.—Horace Bushnell, the New England preacher and theologian, was not only a leader in religious thought but took an interest in civic affairs. A resolution passed by the Common Council of the city of Hartford, Feb. 14, 1876, only three days before Bushnell's death, reads:

> Whereas, The plan of using the land lying between Elm Street and Little River for a public park owes its origin and successful execution in a large degree to the foresight, to the able and earnest advocacy, and the influence, freely and with generous persistence exerted in public, in private, and through the press, of Horace Bushnell. . . .
>
> Resolved, That the public park now commonly called "The Park" be and is hereby named "Bushnell Park."

A paper, "City Plans," written for the Public Improvement Society of Hartford, may be found in one of his volumes, "Work and Play." As the book bears the copyright date 1864 the paper was a pioneer in its line. It may still be read with interest and profit. Some extracts will be given:

> To most persons it will appear to be a kind of law that the city shall stand square with the cardinal points of the compass—north and south, east and west. . . . Whereas in the true economy of health and comfort no single home or city should ever stand thus squared by the four cardinal points, if it can be avoided. On the contrary, it should have its lines of frontage northeast and southwest, northwest and southeast, where shuch a disposition can be made without injury in some respect; that so the sun may strike every side of exposure every day in the year, to dry it when wet by storm, to keep off the mold and moss that are likely to collect on it, and remove the dank, sepulchral smell that so often makes the tenements of cities both uncomfortable and poisonous to health. . . . Conceding then so much in regard to the better convenience of the ractangular form it becomes a problem requiring only to be the more carefully studied how or by what means it may be so far modified as to save it from the insufferable tameness and stupidity of a mere gingham city of the Babylonian or Philadelphian type. . . . I will also suggest that considering the immense importance of a right location, and a right planning for cities, no step should ever be taken by the parties concerned without employing some person, who is qualified by a special culture to assist and direct. Our engineers are trained for a very different kind of service, and are partly disqualified for this, by the habit of a study more strictly linear, more rigidly scientific, and less artistic. The qualifications of surveyors are commonly more meagre still—many of them could not even draw a spiral, if it was wanted, and would for that reason, if no other, march a line straight up a hill, even if it were impracticable. There is even wanted, in this field, a new profession specially prepared by studies that belong to the special subject matter. . . . Nothing is more to be regretted, than that our American nation, having a new world to make, and a clean map on which to place it, should be sacrificing our advantage so cheaply in the extempore planning of our towns and cities. The peoples of the old world have their cities built for times gone by, when railroads and gunpowder were unknown. We can have cities for the new age that has come, adapted to its better conditions of use and ornament. So great an advantage ought not to be thrown away. We want therefore a city-planning profession, as truly as an architectural, house-planning profession. Every new village, town, city, ought to be contrived as a work of art, and prepared for the new age of ornament to come.

Cheaper Reinforced Concrete Construction

In a progress report to the American Concrete Institute at the Chicago convention last February, the Special Committee on Standardization of Units of Design presented some very interesting information to show the causes for excessive costs under which present construction is going on, and how standardization will reduce the cost of building "all along the line." The salient features in the report are liberally abstracted by Concrete, from which the matter following is taken:

The High Cost of Steel Units—and the Reduction.—In the earlier days of structural steel each rolling mill had its own rolls, which varied in small details from those of every other mill and which covered an enormous gamut of sizes.

Designing engineers, in striving for economy, as they thought, called for sizes varying by a few pounds weight for each slight variation of load to be carried, with the result:

1—That the engineering cost was more expensive than necessary.

2—The tonnage output of the rolling mill was reduced, owing to the innumerable changes in rolls required.

3—The work of the fabricating shop, together with the opportunity for error, was greatly increased owing to the possibility of mistaking one section for another which differed only in minor degree.

It was, of course, difficult to get material from several different mills and use it interchangeably, because of the lack of standardization.

It soon became apparent that the multiplicity of shapes and weights put a tax on the use of structural steel that was unnecessary and undesirable.

As a result, the decision to roll only certain shapes and weights was reached, and designers were compelled to adopt these shapes and weights to their use.

Needless to say, a good deal of agitation and misgiving was occasioned, but today we know that the change has been justified, that the smaller number of sections to be obtained are nevertheless sufficient for any case that may arise and that economy has gone hand in hand with change.

The standardization of structural steel is but one example. This has been extended to steel sash and other items used in the construction of buildings.

Inefficiency of Labor.—The lack of standardization, with its attendant bothers, is clearly shown in the products of the various brickyards, hardly any two of which produce brick of a size and color so nearly alike as to enable them to be used interchangeably with the bricks from another yard.

In a time like the present, where there is a decided shortage of brick, this condition is an unmitigated hardship.

Today we are facing an unprecedented demand for new buildings, on the one hand, and a shortage of materials and labor, a condition of congestion and embargoes on the railroads, and an unrest in the labor field that is reflected in a lessened output per man for the hours worked.

It is, perhaps, due to the shorter hours that there seems also to be a falling off in efficiency over that which obtained before 1916.

This can be accounted for, at least partially, if it is remembered that even before the war the workmen did not hit their full stride the moment the whistle blew, neither did they work at full speed to the moment of closing at noon or night.

The condition of an early finish and a slow start obtains today, but owing to the shorter day now prevalent it means an actual decrease in the total output compared with the output of an equal number of hours for the longer day; although in each case, comparing hour for hour, the men may be working at exactly the same rate.

The reduction of output is greatly aggravated by the actual shortage of skilled and unskilled labor. This deficiency is estimated by the brick masons' union to be not less than 10,000 men for their trade alone. Such a lack of workmen, in the face of a tremendous demand for workmen, both by builders and manufacturers, has a tendency to increase the drift from job to job, with the resulting effect that new men must constantly be hired and educated for new duties. It is, or should be, quite apparent, that in a limited period of time it is much harder to teach a man how to perform a number of different tasks, and obtain satisfactory results each time, than it would be to teach one thing, and by constant repetition to reach a high standard of efficiency.

It is quite possible to take men of average intelligence and make them good workmen at any one job in a very short time, providing they are kept at one job without variation.

At the present time the bar mills are being forced to reduce the number of sizes and kinds of bars rolled. This is largely an economic condition. The men in the rolling mills are paid on a tonnage basis; the overhead of the mill, too, is charged against the tonnage output. The mills, recognizing these facts, are today rolling approximately two-thirds of their output in sizes above the ¾ in. base size and one-third in sizes smaller than base.

To take a typical case, one ton of ⅜-in. round bars would equal 5.320 lin. ft., whereas it would equal but 1.350 ft. of ¾-in. round bars.

Unquestionably, the cost of labor and overhead on the larger size must be much less per ton than that of the smaller.

It is very probable that, for the immediate future at least, the intermediate 1/16-in. sizes will be abandoned and designers of concrete structures will be forced to content themselves with sizes that advance by even eighths.

Citing again the steel sash shops as an example of the tendency toward standardization, just so long as the regular stock sash with flat heads and horizontal pivoted ventilators are ordered a reasonable time of delivery may be obtained. If, however, to satisfy a whim of the owner or engineer, vertically pivoted ventilators are called for, the whole operation of the shop is thrown out of gear.

The workmen in the sash mills are paid a regular rate plus a bonus for output. Just as long as the work is standard and regular the men earn a bonus worth while. Inject, however, something special, and the routine of the factory stops; the men do not make their bonus, with the result of a prompt disintegration of the morale and a great falling off of efficiency.

Examples may be multiplied, but this will suffice to indicate the desirability of standardization, not only in rolling mills and factories, but in the closely allied industry, the manufacture of buildings.

Relative Cost of Labor and Materials.—In 1916, on an average job, a division of the money spent in producing the structure would indicate that labor cost about 30 per cent and materials purchased about 70 per cent of the total. Today the division would be approximately 40 per cent for labor and 60 per cent for materials, and it is predicted that in the near future, owing to the rising price of labor, this division may be more nearly 50-50. As the labor cost increases it becomes self-evident that more and more material can be used, if thereby labor can be reduced.

To apply this line of reasoning directly to the individual parts of a concrete building is not simple.

It is very difficult to make it clearly obvious that where a number of beams in a building are of one size, although the loading may vary sufficiently to allow decreasing the depth or the width in some instances, nevertheless such change, while it would undoubtedly save material, would probably make the saving at the expense of a considerable extra cost for labor and supervision.

It is proposed by the committee to submit at the next meeting of the American Concrete Institute actual design and estimating data illustrating the possibilities of a greater degree of unification, particularly relative to footings, columns and beams.

Supposed Economies Increase Costs.—In the meantime, a few specific instances of details that apparently economize but actually add to cost will be indicated.

Blueprints for a building recently submitted showed a total of 54 footings. These footings were in the form of truncated pyramids with a square or rectanglar base. Slight variations in the size and shape of the base and of the top on which the column rested resulted in 19 separate types of footings. Of this number, 14 occurred once, 2 occurred twice, 1 three times, 1 occurred five times, 1 twelve, and 1 sixteen times.

The footings as detailed doubtless saved some concrete over that required by simple steps, but the saving was made at the cost of some very fussy and expensive form work.

A second example is the case of a building with different story heights.

While this may sometimes be necessary to tie into existing buildings, variations of this sort require piecing out or cutting off all supporting shores under the floor forms, as well as the column forms themselves, and is an added expense.

On another building of flat slab design, with circular interior columns, the column caps were called for 6 ft. 6 in. in diameter.

The standard head made by the metal column mold companies is 6 ft. in diameter. This head was therefore a special piece of equipment and cost considerably more than the standard would. If the head had been made the standard 6-ft. diameter, and ½-in. extra concrete added to the depth of the plinth, the shearing value of the concrete would have been the same and the total volume of concrete used would have been no greater, and a saving would have been made in cost.

To touch on wall and interior columns in general, it is undoubtedly economical to keep the column size unchanged through at least two stories, varying the column mix and, if necessary, having some excess strength in the upper lift. This is particularly true where the columns are square or rectangular and wooden forms are used.

Still another point in connection with wall columns in flat slab buildings may be illustrated. In the earlier days of flat slab construction the use of drop panels was largely confined to the interior columns, the wall beam was built usually entirely above the slab, and a simple haunch on the inside face of the wall column below the slab sufficed for all but extraordinary demands.

Today, designs frequently call for a plinth at the wall column as well as at the interior. As this plinth extends either side of the column, it necessitates a small drop beam, the depth of the plinth being carried across the head of the window, and in order to obtain sufficient strength it is also necessary to carry the beam above the slab.

Probably it will not be disputed that this is more expensive than a simple beam above the slab, and usually performs no function which could not have been adequately arranged in a simpler way.

Another condition that occasionally arises is that where it is specified gravel can be used for aggregate in the floors, beams, etc., but that broken stone must be used for aggregate in the columns.

In many parts of the country gravel is the only easily available supply, or it can be purchased more economically than broken stone. Under these conditions gravel would naturally be desirable, but its use would mean getting aggregate from different stock piles and routing each batch of concrete on the floor so that no gravel concrete was placed in a column.

The roof of a building also requires careful attention. It is desirable that the regular floor forms be used with as little variation as possible.

The story height should be the same as that of the floors below.

The ceiling should remain flat, and it is a question if it is necessary to pitch the upper surface, provided a good job is made of the roofing.

Summary. Footings: Where the sides of footings are sloped the number of forms to be made should be reduced to a minimum by utilizing the same sloped form for footings even when the area of the base courses below the sloped portion are different sizes.

In many cases a stepped-up footing without steel will prove more economical than reinforced concrete footings. Care should be taken in the use of plain concrete not to exceed a reasonable unit in tension.

Columns.—In order to effect economies in the form work it will often be found desirable to maintain the same cross section of column through several stories. In the case of interior columns where metal forms are used it is important that that portion of the metal form which adjoins the floor construction shall be uniform in the several stories to avoid the changing of the floor forms. When metal forms are used for interior columns, the reduction in the size of column, if made at all, should be made in every other story. The vertical steel reinforcement should be made up of as large bars as are consistent to good practice in order that the handling expense may be reduced to a minimum.

Beams and Girders.—In determining the depth of beams and girders of floors, a careful study should be made to determine the depth which will give the minimum total cost for the reinforcing steel and concrete combined. This should be considered, although very often the minimum depth to be used for a certain span or the criterion of shear will govern the depth actually determined upon.

In general, the forms for roof construction should be the same as those for the floors, in order to avoid the expense of remaking the forms. It is very seldom possible to remake the forms and save enough concrete to make it worth while. Every effort should be made to so plan the construction that forms can be used from floor to floor.

Story Heights.—From the standpoint of economy, it is desirable that the story heights be such that it will not be necessary to lengthen out the column forms to provide for the upper stories.

Steel Reinforcement.—In order to avoid excess of labor costs in the field, it is desirable to reduce the number of lengths and sizes of reinforcing bars to a minimum, even if in so doing a slight excess in steel reinforcement is sometimes necessitated. In this connection, the number of bars used in any member should be reduced to a minimum, provided all the requirements for bond, etc., are taken care of. A minimum number of stirrups of maximum size should be provided to reduce labor cost.

The Distribution of Wealth*

By GEORGE E. ROBERTS,

Vice President National City Bank of New York

The fundamental cause of most of the misunderstanding which exists is that the modern industrial system has developed beyond the view and comprehension of the average man. He doesn't follow all its complications, he is not familiar with the economic laws and doesn't know whether he is getting a fair division or not, but suspects not.

Lack of General Economic Knowledge.—It is no reflection upon his intelligence to say this. Thousands of people go through our schools and universities and come out without any clear ideas on the subject, and some of them remain in the universities as teachers. Not one person in twenty who essays to discuss wealth and incomes says anything about the fundamental principles which lie at the basis of industrial progress.

The workingman reads and is told of vast accumulations of wealth in the hands of a few. It is said that 2 or 3 per cent of the people own most of the wealth, and as a matter of fact it is true that only about 3 per cent of the population paid any income tax last year, although that doesn't sound so bad when you reflect that only about 20 per cent of the population are heads of families and the heads of families usually hold the property. But the working man hears of personal incomes that are far beyond the needs of any man or family, and he thinks of these as meaning deprivation to the wage-earning class. He thinks of them in comparison with his own income or the average income. The comparison is almost wholly misleading, and I would like to point out the manner in which it is misleading. I want to lay down the proposition that the real distribution of wealth is not by ownership or income but by consumption. It is only as an individual consumes wealth or uses it exclusively that he deprives other people of it or reduces the common supply.

We talk about capital and income in terms of money, but money is only the medium of transfer. Wealth actually exists in the form of tangible property, and in discussing distribution it is better to think of it as people use it.

"Consumable" and "Productive" Wealth.—Wealth is of two general classes. There is what is known as "consumable goods" consisting of things that are consumed or used directly, such as food, clothing, dwellings, furnishings and such like. The other class of wealth consists of property used in the production of consumable wealth, such as land and factories, or property, which renders public services, such as railroads and other utilities. Wealth of this second class is not to be valued by itself. It exists, not for itself, but to produce a flow of goods and benefits, and all the value comes out in the flow. The value of a farm, aside from the fact that the farmer lives on it, is for the crops it will yield; the value of a factory is for the goods it will turn out; and the real distribution of benefits from all productive properties is in the distribution of the goods they produce or the services they render. And right here is where nine-tenths of the misunderstanding over the distribution of wealth arises. I repeat that the right place to measure the distribution is not at the point of ownership, or production, but at the point of consumption. The great consuming public is the chief beneficiary from increasing production.

Measuring Wealth at Point of Consumption.—And when you come to measure distribution in this manner you get a result very different from the representations commonly made. Two or three per cent of the population does not consume most of the food supply, or wear most of the clothing, or burn most of the coal, or occupy most of the houseroom, or do most of the riding on the railroads, or even own most of the automobiles. The vast commerce of this country and traffic upon the railroads is not in supplying the wants of 2 or 3 per cent of the population. It is no small section of the population that is behind the great trade going on all over this country today, the character of that trade gives every evidence of a widespread distribution of products.

In short, the whole theory that a comparatively few people enjoy most of the benefits of existing wealth breaks down completely under examination. The fact is that in proportion to the total social product the share consumed by the rich is insignificant. The large incomes in the main go back into industry to increase production for the public market, and the benefits inure chiefly to the public.

Fallacy of Radical Argument.—The whole radical argument is based upon the idea that all the wealth employed in industry benefits nobody but the owners. It proceeds upon the theory that all the increasing supply of goods and services resulting from the investment of private capital is absorbed and consumed by the capitalists. The idea is pure theory, unrelated to the facts. It is like claiming that nobody ever got any benefits from the development of the steam engine but the owners of engines, that nobody has been benefited by the construction of railroads but the owners of railroad shares; that nobody has been interested in the development of the textile industry but the manufacturers, and so on around the circle of industries. The position only needs to be stated to make the fallacy apparent.

Industry's Debt to Capital. You are a society of engineers. You are familiar with the progress of industry, and you know the means by which production has been increased to meet the needs of a growing population and raise the standard of living for the masses. It has been done by improving the methods of production and by the use of power and machinery. It has been done by the development of the industrial plant, and that plant represents the profits and savings of individuals. Those savings and investments have lifted the whole level of social life far above what it was before capital became an important factor in industry. If you want to see a state of society where capital is no such factor in industry, go to India or China. If you want an abundant distribution of the comforts of life you must first have efficient and abundant production of them. It is clear that you cannot place distribution ahead of production, and I think it can be made equally clear that as production increases distribution increases and broadens to serve the common welfare.

The history of industrial development shows that capital has been a constantly increasing factor in production. Our census reports show that in 1899 the amount of capital employed in manufacturing establishments in the United States averaged $1,770 for each person employed, that five years later in 1904 it was $2,117, in another five years, in 1909, it was $2,488, and in 1914 it has risen to $2,848. This increasing investment has meant that more and better equipment was being provided, that better tools were being placed in the hands of labor and that the production of consumable goods for the public market was being increased. In the 10 years from 1899 to 1909 while the population of this country increased 21 per cent, the amount of capital invested in manufacturing increased 105 per cent, and the amount of steam or hydro-electric power employed in manufacturing increased 85 per cent.

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*From an address before the Society of Industrial Engineers.

Productive Property Part of Society's Equipment.—I want to enforce the point that all this productive property, although privately owned, is part of the equipment of society; that it promotes the common welfare and is necessary to the common welfare. It is doing the same work that it would do if it was owned by the State, and as we believe, doing it more effectively than if the Government owned it. When people advocate the ownership of the railroads and other industries by the Government the thought in their minds is that they will thereby avoid paying profits to the owners, but they forget that if there were no surplus earnings, nothing left over after paying expenses, there would be no capital for the improvement and enlargement of these services and no industrial progress. If there had been no profits or savings in the past there would have been no such industrial equipment as we have today, and social conditions would be far worse than they are now.

If we had a socialistic State, all of this property would have to be created, all of these productive agencies would have to exist, and they would have to be provided by reserving capital from distribution just the same as now. And so I repeat, that so much of a man's income as is invested productively is not to be counted as though it was devoted to himself exclusively. A man's share in the real distribution is what he consumes and no more; the remainder of his income, if put back into production, as practically all savings are, is in the service of the public, just as much as though he turned it over to the Government. What better could the Government do with it?

Society Would Retrograde Without Capital Accumulations. There is another fact to be emphasized in relation to the importance of capital accumulations. It must be remembered that as population increases, the task of providing for its subsistence becomes more difficult, unless the methods are improved. The richest or most accessible lands are occupied first, and after they are taken, population spreads over the poorer lands or those which require more labor for their development. And then the great stores of natural wealth in the soil, timber, and mineral resources of a new country are gradually exhausted, so that the fertility of the soil must be maintained or replaced by methods of cultivation which increase the costs; timber must be grown by cultivation; substitutes for the minerals must be found.

We have occupied the rich prairie lands of this continent and the prices at which they are selling show how much more they are worth than the lands which are yet to be brought under cultivation. Food and clothing materials for our growing population will cost more in the future because it will cost more labor to produce them. All raw materials are costing more as population increases and the natural resources are impaired. There must be constant improvement in the methods of industry to offset this tendency or society will not even hold its own, and such improvements are commonly in the form of labor-saving machinery. In other words, instead of dividing up and eating up all that is produced as we go along, some of the wealth that is produced must be withheld from consumption, and devoted to making industry more productive in the future. Otherwise, the early generations who have occupied this country will have exploited it and left nothing to compensate their children for the harder task of making a livelihood which will confront them.

The Master Principle Which Governs Distribution.- The average man, however, while agreeing that production must come before distribution, is disposed to insist that he must know more about distribution before he will have much interest in increasing production. He wants to know what assurances there are that after production has been increased he will get a larger share. The answer to that is given by pointing to the natural law which governs distribution. Follow me for a moment while I state it. In all progressive countries capital increases faster than population, and faster than the labor supply. I have referred to the census figures which show that in this country from 1899 to 1909 the population increased 21 per cent and the amount of capital increased 105 per cent. There is no way in which capital can be put into use except by employing labor. Every dollar of new capital accumulated creates a new demand for labor, and with capital increasing faster than population, labor comes inevitably into a constantly stronger position. And not only do the new supplies of capital create a constantly increasing demand for labor, but the employment of both labor and capital is mainly in providing things for common consumption. The great bulk of the industrial product must be sold and distributed back to the masses of the people.

Capital's Sole Use.—Practically all of the great expenditures of construction and equipment which we see going on all about us are for the purpose of serving in some manner the masses of the people—of supplying something that they want and can afford to buy. There is no other employment for capital. It wouldn't take many factories or railways or costly terminals to supply the wants of the rich—there are not enough of them! It is the wants of the millions which keep the wheels of business moving. And with capital increasing faster than population, with this enormous increase in equipment and the improvement in methods and machinery, we are bound to have a constant increase in the production of commodities per head of population, and the only way these commodities can possibly be distributed is by such a continual readjustment of wages and prices as will enable the masses of the people to buy them. There would be congestion in every line of production, and enterprise and industry would choke down, if the purchasing power of the masses did not constantly increase.

Every new fortune, every dollar of new capital goes forthwith to work as a producer, multiplying the things the world wants, and if things increase faster than people, what must the tendency inevitably be?

How Workmen Can Restrict Production.—Several years ago, when I was in the Government service, I received a letter one day from a Colorado Congressman, complaining that a mechanic in the Denver Mint was working as a strikebreaker during his vacation. I had occasion to visit the Mint later and showed the letter to the employe. He explained that he was trying to pay for a home and had not thought it wrong to earn some money during his vacation. The "strike," he said, was a technical one, declared a year or more before, because the shop was an "open" one. Then he told me that he had worked at that shop before he entered the Mint, and explained how it came to be made an "open" shop.

The shop was running upon a specialty, a small tool used in mining operations which was made upon a lathe. When he began he was green at the work, but he improved rapidly, and in a few days the foreman came to him and told him that he was killing the job. He thought the foreman meant that he was not turning out the tools as fast as he should, and he said: "I know I am green at it, but I am gaining. Last week I could make 30 a day, but yesterday I made 35 and I think I will soon make 40." "Good God!" said the foreman, "25 is the stunt!" The men with the foreman in collusion, were deliberately restricting the output of the shop.

Now, of course, those men thought they were doing something that would benefit other workingmen; what they were really doing was raising the cost of a tool that other workingmen had to buy. To whatever extent that practice pervades industry it enters into the cost of living, it's a drag upon industry and an abstacle to progress. It is economically wrong and morally wrong, and it dwarfs the ability of the workers themselves. No man can be a full man, no man can do himself justice or come into his full powers unless he does his honest best, not merely for his employer, but for the community of which he is a part and which is his real paymaster in the end.

Ignorant Conceptions Must Be Dissipated.—That sort of thing is the result of ignorance; it is the result of a mental attitude and the only remedy for it is in a change of mental attitude. New light must come into a man's mind, a spread of enlightenment, as the morning dawn steals over the earth.

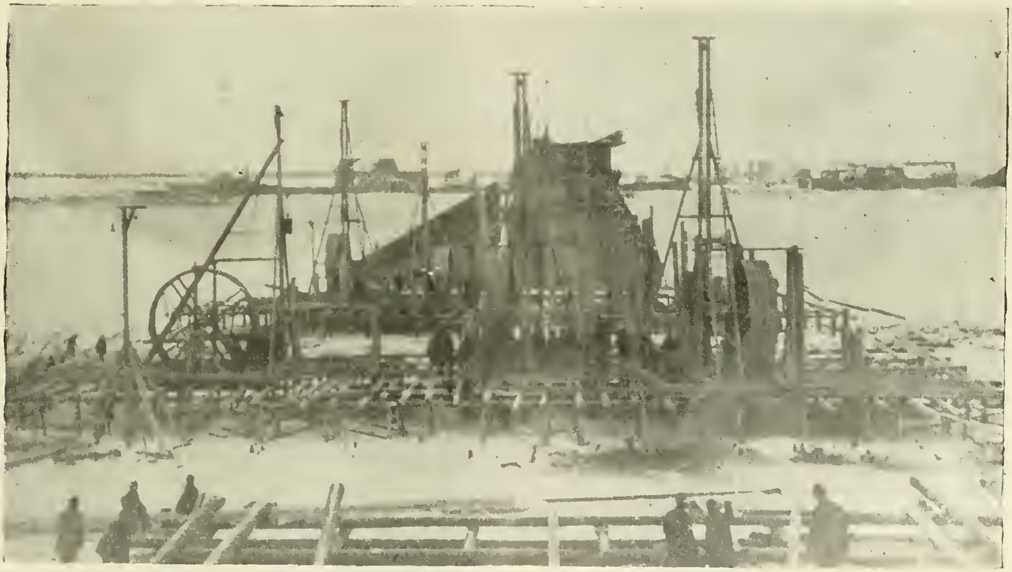
This ignorance exists, it pervades industry, it keeps down production, it keeps down wages, it is a practical problem for management to deal with as it does with any other. A problem in psychology is just as real as a problem in chemistry.

and it must be dealt with in the same spirit, with the same patience, and by the same painstaking methods, as a problem in chemistry.

And the ignorance is not confined to one class. If the wage-earners are sometimes mistaken, have the leaders of industry and society always been wiser? Have they always known the real springs of wealth, the real source of efficiency and always taken the larger view? Have they always understood their own best interests? Have they always appreciated that it was as truly in the employer's interest that a workman should be in fit condition for effective labor as that a workhorse or machine should be in fit condition? Have they always understood that a man works not only with his hands but with his spirit, and have they appealed to the spirit? Have any of us ever had an adequate idea of how the national wealth might be increased by developing the capabilities of the people?

Building a Bridge Without Tools

Dvinsk, recently occupied by the Poles, is perhaps the most completely demoralized city in the world. The war has completely wrecked the civilization of the people, and today they are living in the primitive way of their peasant ancestors. Cave dwellers never lived more primitively than these once prosperous twentieth century citizens. Without light or fuel, without water or plumbing, food or clothing or shoes, the throwback to the primitive which the life of the people of Dvinsk has undergone is disastrous. When the American Red Cross arrived there it found 30 or 40 dying daily from starvation. The situation is one of the most baffling that the Red Cross has undertaken in Europe.



Wooden Pile Drivers at Work on Dvina Bridge.

There are no industries left in Dvinsk, once one of the busiest centers of Western Russia. All machinery, all tools have disappeared—carried off or wrecked by the contending armies. Recently, when Polish engineers set to work to rebuild a wrecked bridge across the Dvina, the only tools they had to work with were hatchets. The timbers of this bridge are all hand hewn, yet it is noticable how evenly they are squared and finished off. For putting down the piles, drivers were built—all of wood. They consist of huge treadmill wheels, 12 or 14 ft. in diameter and 4 to 5 ft. wide, inside which men walk to turn the windlass that manipulates the wooden hammer.

Storing, Piling and Handling Sacked Cement

Careful storing of cement that is not to be used immediately is necessary. Cement will absorb moisture so readily that unless properly stored and piled it will soon be unfit for use. Useful suggestions on these points are given in the May-June Concrete Builder, a publication of the Portland Cement Association. A building that can be kept absolutely dry at all times is necessary for the proper storing of cement. Where a board flow is used it should be double with a layer of tarred paper between two sections. This construction makes for dryness. The walls of a frame building may be made dampproof with one or more thicknesses of tarred paper. For the roof of such a structure, tarred paper roofing on sheathing, laid with tight joints lengthwise or in clapboard fashion crossways is satisfactory. At least a foot for drip or overhang should be allowed on all sides. The roofing should be firmly fixed and watertight so that it cannot be raised by wind, and the rain cannot beat in under the eaves. It is advisable to have no more windows than absolutely necessary.

If a permanent structure is to be erected either monolithic concrete, concrete block or concretestructural tile will be found well suited for the purpose. For convenience in loading and unloading, the floor should be about 4 ft. above the ground, which is the height of the average car floor and wagon or truck body.

This floor should be of 1:2:3 concrete, placed on a well compacted earth or cinder fill to insure dryness at all times.

For a 1-story building such as is usually used, a 6-in. reinforced wall will be found strong enough. This, with either a reinforced concrete roof or one covered with cement asbestos shingles or concrete roofing tile, will protect the cement from dampness.

As portland cement weighs practically 94 lb. per cubic foot, the beams of the floor elevated above the ground must be strong and be supported at sufficient intervals by concrete piers. As in the case of a temporary storehouse, no more windows than absolutely necessary should be provided.

In computing the size of storehouses, experiments have shown that each sack of cement occupies between 1.25 and 1.50 cu. ft. of space. This allows for the unoccupied spaces caused by piling.

Sufficient space must be provided to allow for alleyways between piles and the walls, and to separate the piles themselves. If the cement is to be stored for any length of time the various shipments should be separately piled so they can be removed from storage in the same order as put in.

When cement is stored in high piles for a long time there is a tendency for the lower layer to harden or cake. This is known as "warehouse set" and is due to pressure during storage. Such cement can be reconditioned by rolling or dropping the sack on a solid surface. When stored for a short time, piles may be 12 or 15 sacks high, but if stored for a long period it is not advisable to build piles over seven sacks in height. This method of stacking will largely eliminate "warehouse set."

Where the concrete floor has a well tamped cinder base, the cement may be piled directly on the floor. Quite a number of dealers have piled their sacked cement directly on such a concrete floor for a number of years and report no difficulty from caking. To avoid possible danger from dampness, cement should not be piled directly against the side walls of the building, but an alleyway left betwen the walls and piles.

To lessen the danger of toppling over it is a common practice to lay the bags as a mason would say "in headers and stretchers," that is, alternately lengthwise and crosswise so as to tie the pile together. If the sacks are to be piled seven high, however, there will be little danger of toppling, if they are laid up straight. This method facilitates handling as the hand trucks used in transporting cement from car to storehouse usually carry seven sacks.

The most common method of handling is by hand truck. Seven bags are placed on the truck and if the pile in the warehouse be of this height the cement can be unloaded with little effort. Where grade conditions permit, dealers have made unloading cement easy by the use of a metal lined chute. Where trucks are elevated this is particularly adaptable. Perhaps the most widely used means of unloading by gravity is by roller conveyors. Wood pallets are generally made upon which four or five sacks can be piled and slid down the conveyor. Ten or a dozen pallets are used and when the total number has been sent down, the pallets are racked up and pushed back along the conveyor by the man who does the piling.

To Find Out Position of Presidential Candidates on Questions of Interest to Engineers

The American Association of Engineers, through its Secretary, has addressed a letter to each of the candidates for the presidency, in which the candidate is requested to give an answer to six questions, designed to bring out his position on subjects in which the engineer will be especially interested. These questions are:

1. Are you in favor of a National Department of Public Works, for tthe purpose of reducing and co-ordinating the present number of bureaus and commissions, and reducing the useless expenditures of money incident thereto?

2. Are you in favor of assembling and co-ordinating all the engineering and construction enterprises of the Government (excepting the purely military works) in a department such as the National Department of Public Works, to the end that economy and efficiency will be obtained?

3. Do you favor the appointment of an engineer of recognized ability and unimpeachable character as a member of the Inter-State Commerce Commission?

4. Do you favor the budget system of appropriation of public funds?

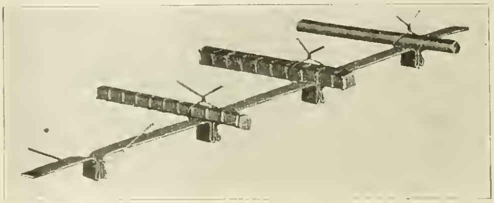
5. Do you favor the reclamation of waste lands by drainage, irrigation, flood control or other methods?

6. Do you favor giving the settler the advantage of procuring the land by a sound financial system such as is provided by a rotating fund?

Contract Let for the Largest Wireless Station in the World. The contract for the construction of the new wireless station to be built by the Radio Corporation at Rocky Point, L. I., has been awarded to The J. G. White Engineering Corporation, 43 Exchange Pl., New York City. Work will be begun immediately. The station when completed will have a diameter of more than 3 miles with 12 sets of antennae, strung to 72 ft. self-supporting steel towers 400 ft. high, set up a mile and a half away from the central power house, and will probably cost about $10,000,000. It will be divided into five units for communication with Argentine, France, Scandinavia, Germany and one with Italy and Poland.

A New Bar Spacer

A new bar spacer for reinforcing steel for concrete slabs has been brought out recently by the Universal Form Clamp Co., 14 North May St., Chicago, Ill. Its use is claimed to assure the architect and contractor: That the bars in the slabs are all supported the proper distance from the forms; that the bars when placed are spaced as called for by the plans, and that when so placed, the steel cannot be dislodged. The supporting device consists of four laps of metal; the middle loop being directly under the load prevents any wedging action by the bar. The tie is 16-gage annealed wire. These spacers are detailed directly from the plans, to contain the number of bar positions and the spacing called for. They are made in three heights: to support the steel, ½ in., ¾ in. and 1 in. above the forms.



Universal Slab Bar Spacer.

Personals

F. D. Hain has been reappointed city engineer of Altoona, Pa.

E. H. Jeffries has been appointed city engineer of Manteca, Calif.

F. A. Jones has been appointed office engineer of the Boston & Albany R. R.

Joseph A. Martin has been appointed commissioner of public works of Detroit, Mich.

Charles S. Donnelly, heretofore chief draftsman in the office of the city engineer of Kansas City, Mo., has been appointed assistant city engineer.

Older & Quinlan announce that their engineering practice has been merged with the practice of Arthur W. Consoer under the corporate name of the **Consoer Engineering Co.** Clifford Older is president of the company, George A. Quinlan is secretary and treasurer, and Arthur W. Consoer assumes the duties of vice-president and business manager. Executive offices are at 1651 Monadnock Block, Chicago. The company will conduct a general engineering practice in municipal paving, water supply, sewerage, drainage, bridges (particularly for cities and drainage districts), reinforced concrete grain elevators, fertilizer, storage tanks, coal pockets and industrial buildings.

Captain O. G. Baxter has resigned as senior drainage engineer, U. S. Bureau of Public Roads, and has established the Baxter Engineering Co., with offices at Room 4, Moore & Turner Bldg., Little Rock, Ark. Capt. Baxter served 11 months in France as company commander in the 601st Engineers and as topographic officer in the 108th Engineers. From November, 1918, to February, 1919, he was chief instructor of the Pioneer Section, Army Engineer School, A. E. F. He has been on Government drainage work since 1907 and since 1910 has been in charge of the Arkansas district embracing Arkansas and the adjoining states. The company will specialize in drainage and flood protection projects.

Elwyn E. Seelye, consulting engineer, 101 Park Ave., New York City, announces the formation of a partnership to be known as Seelye & Fraser. The new partners will be Edwin A. Fraser, formerly with the Truscon Steel Co., A. L. Stevenson and C. H. Hamilton. Mr. Stevenson will have charge of the designing department and Mr. Hamilton the concrete detailing department. An associate structural steel detailing company has been formed under the firm name of Seelye & Tarbell. Chas. E. Tarbell for a number of years was connected with the Westinghouse, Church, Kerr Co., and during the war was structural engineer on the $60,000,000 Government nitrate plants at Toledo and Cincinnati.

Philip Burgess and **Chas. F. Long** announce the dissolution of the partnership of Burgess & Long heretofore conducted at 8 East Long street, Columbus, O. Mr. Burgess has entered into a new partnership with Chester A. Niple, who has been connected with him for the past nine years, and with Warren F. Hopkins, who has had 15 years' active practice as superintendent on the construction of many various municipal projects. The new firm will operate under the name of **Burgess & Niple**, and will be located at 141 East Broad St., Columbus, O. They will continue the practice of general engineering, specializing in municipal improvements and in addition will take contracts, as constructing engineers, for municipal and industrial developments.

J. W. Johnston has been appointed district engineer in charge of the Milwaukee office of the Portland Cement Association. Mr Johnston has been with the association since July, 1916. Before that he had been city engineer of Sioux Falls, S. D., county engineer of Minnehaha county, S. D., and had served in various engineering capacities on railroad and general contracting work. For the past two years he has been district engineer in charge of our Parkersburg, W. Va., office. J. H. Riddle, who since 1916 has been connected with the Parkersburg, W. Va., office of the Portland Cement Association, becomes district engineer in charge of that office, succeeding J. W. Johnston. Mr. Riddle formerly was county engineer of Roane county, West Virginia

Roads and Streets Monthly Issue

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Roads and Streets—1st Wednesday
(a) Roads
(b) Streets
(c) Street Cleaning
(d) Municipal Miscellanies
(e) Management and Office System

Waterworks and Hydraulics—2nd Wednesday
(a) Waterworks
(b) Sewers and Sanitation
(c) Irrigation and Drainage
(d) Power and Pumping
(e) Management and Office System

Railways and Excavation—3rd Wednesday
(a) Excavation
(b) Management and Office System
(c) Quarries and Pits
(d) Steam Railways, Construction and Maintenance
(e) Electric Railway Construction and Maintenance

Buildings and Structures—4th Wednesday
(a) Buildings
(b) Bridges
(c) Harbor Structures
(d) Miscellaneous Structures
(e) Properties of Materials
(f) Management and Office System

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Why Do So Many Labor Unions Restrict Output?

Few men are so stupid as to be unable to see that if all workmen were to curtail their daily output there would be fewer necessities and luxuries available for distribution, and a correspondingly lower average income for all people. Then why is it that so many labor union leaders countenance, if even they do not actually advocate, a restriction of output on the part of union members? It is clear that this policy must be founded on what the union leaders conceive to be good economics from the point of view of union workmen, if not from the point of view of other people. Let us consider the unionists' point of view.

Labor union dealers contend that capitalists have always taken the major part of all that is produced, and that the unalterable policy of capitalists is to give to workmen only enough of the total production to provide the bare necessities and a very few luxuries. They also frequently cite statistics that seem to bear out their contention. Those who believe this contention to be true are not apt to exert themselves to increase their output. If, for example, workers receive only 25 per cent of all that is produced, who can blame them for not increasing their production? But, it will be replied, it is not true that workers receive only one-fourth of the total product; they actually receive three-fourths.

Thus the issue is clearly joined, and if employes can be persuaded that their aggregate income is approximately three-fourths the total income, most of the opposition to increasing their output will cease. The fact is, however, that they believe that they are "getting the short end of the stick." Does it not therefore became a matter of supreme economic importance to ascertain and publish the facts?

We believe that the statistics of manufacturing, mining, farming, etc., should be so gathered by the government as to show clearly the gross and net income and the part of the net income that goes to the owners of property in the form of interest, rent, dividends and profits. Such a statistical census should be taken every five years. A manufacturing census is now taken every five years, and it need contain only a small amount of additional information to make it serve the purpose now under consideration. Indeed, it is practicable at present to prove from this census the falseness of the claim that most of the income goes to capitalists and only a minor part to employes. Thus, for the calendar year 1914 the census shows the following relative to the manufacturing industries of the United States:

Gross value of products	$24,246,000,000
Cost of materials and mill supplies	14,368,000,000
Value added by manufacture	$ 9,878,000,000
Deduct salaries of 964,217 employes	1,287,000,000
Balance	$ 8,591,000,000
Deduct wages of 7,036,337 employes	4,079,000,000
Total	$ 4,512,000,000
Deduct taxes	441,000,000
Balance	$ 4,071,000,000
Deduct contract work	199,000,000
Balance	$ 3,872,000,000
Deduct rent	141,000,000
Balance	$ 3,731,000,000

It will be noted that office supplies and insurance are not among the operating expenses above given, nor is there any allowance for plant depreciation not covered by current maintenance expenses. It is our opinion that this annual depreciation item would total fully 6 per cent of the 22,791 million dollars of capital investment. If so, there should be deducted 1,367 million dollars from the 3,731 millions, leaving a balance of 2,364 millions, or about 10 per cent on the 22,791 millions invested capital. But since insurance and other expenses must come out of the 2,364 millions, it seems clear that for the year 1914, the true net earnings of all manufacturing plants in America was less than 10 per cent on the invested capital, or about 2,300 millions. Contrasting this with the 24,246 millions gross value of manufactured products, we see that capital must have earned somewhat less than 10 per cent of the year's gross revenue. We also see that salaries and wages totaled 5,366 millions; hence if the net earnings available for dividends, interest and profits were as much as 2,300 millions, the employes received $2.33 for every $1 that the "capitalists" received, or that of the $3.33 distributed among "capitalists" and employes, the latter received 70 per cent.

In his "Wealth and Income," Prof. King estimates that, taking the nation as a whole, capitalists receive 25 per cent of the total income. Unfortunately, any such estimate involves making several assumptions, which may be questioned. Most of these assumptions could be made unnecessary were the census so taken as to secure a few additional facts. Most of these needed facts are given in the income tax statements, so that no appreciable burden upon manufacturers and others will be added by asking for the necessary data.

Labor union leaders often misuse the census data, but usually because the data are incomplete. Thus the absence of any census reports on the annual depreciation of manufacturing plants may lead an inexperienced man to infer that the net earnings or "profits" of manufacturing industries in 1914 were 3,731 millions, the "balance" above given; whereas it is certainly much less, and probably does not exceed 2,304 millions after deducting the depreciation. Of course the publication of the elements of cost would not deter dishonorable labor leaders from attempting to deceive their followers by misusing the data. But we believe that such leaders are relatively few in number.

Ignorance of the facts is the principal cause of the prevailing belief among workers that they are not fairly treated by employers; and it is the resentment begotten of this belief that is at the bottom of most of the resistance to speeding up their output. It lies within the power of the government to secure all the facts needed to remove this ignorance and its consequent ill effects.

Why Highway Engineers Should Study the Causes of Price Changes

Several states have curtailed their road-building program in the belief that construction prices will be considerably lower in 1921 than they now are. Undoubtedly this step has not been taken without securing the advice of the engineers of the highway departments. Since such advice can not be intelligently given without studying the causes that affect commodity prices in general, it is evident that civil engineers should investigate price economics in a much broader way than has been their custom.

Prior to the world war it sufficed for a highway engineer to be familiar only with road construction and maintenance costs. But the day has passed when that knowledge is enough. The engineer must now study the causes that affect price levels, that is, "index prices" of all commodities; for he who fails to do this is likely to advise his employer incorrectly. It will not do to say that because present construction costs are double what they were in 1914, therefore construction work had better be postponed. It will not do to infer that because clothing prices have recently decreased somewhat, therefore construction prices will decrease correspondingly. Engineers must acquaint themselves with the phenomena of price changes, not merely in their own special field but in all fields. Fortunately this is not a difficult thing to do.

The 20-page article on price levels in our April 7 issue should assist any studious engineer to an understanding of the phenomena of price changes. In that article it was shown that the average price of all commodities is a direct function of the per capita currency, its rapidity of turnover, and inverse function of the per capita efficiency of production. Knowing these facts, few engineers will be apt to advise their employers that construction costs will recede greatly in the next few years.

In our issue of April 14 a history of prices following our civil war was given, from which it is clear that the prices of construction materials did not recede appreciably till the panic year of 1873, or eight years after the close of the civil war, although clothing prices dropped 50 per cent within four years after 1865, while food prices dropped 30 per cent in the same four-year period. In the April 7 article it was shown that average daily wage rates rose 45 per cent during the four years of the civil war, and that they continued to rise, in spite of heavy immigration, reaching their peak in 1869 when they were 67 per cent above the level of 1860. It was not till the panic of 1873 that wage rates receded from this peak.

We can not urge too strongly upon our readers the advisability of studying with great care the articles on price levels published in our issues of April 7, 14, 21, May 5, 12 and 26.

Should Motor Truck Express Rates Be Regulated by Public Service Commissions?

Almost a year ago the Railway Commission of Nebraska put into effect a classified freight rate schedule for motor trucks. The commission also required every truck owner operating for hire to keep a double entry system of books to show plant investment and operating expenses in detail. A few months hence these costs will doubtless be published, but it is questionable whether they will be of much value. The annual expenses that will thus be secured by the Nebraska Commission four or five years hence will be more useful, for by that time there will be a greater proportion of old motor trucks in service and the maintenance expenses will then be more truly indicative of what normal upkeep costs are over a term of years. Even then there will probably remain unanswered questions as to the effect of different kinds of road, speed of transport, etc., upon maintenance expenses.

While the publication of these trucking cost records by the Nebraska Commission will eventually provide useful data, it is a question whether this gain and other gains that flow from such public regulation will not be more than offset by the deadening effect of rate regulation. We have but to consider the present condition of steam and electric railways to realize that government regulation of transportation rates has thus far been anything but ideal. Capital has been driven out of these fields to an extent that the general public is only just beginning to realize. May history not be about to repeat itself in the field of motor trucking? Railway commissions are usually so anxious to give the public the lowest possible transportation rates that capitalists find it preferable to invest in other things than railways. Are railway commissioners apt to be more liberal and far-sighted in their regulation of motor truck rates than they have been in their regulation of railway rates? Time will tell, but the editor would not invest a dollar in a motor trucking company in Nebraska or in any other state that regulates trucking rates, until public utility laws are so changed as to insure a long tenure of office for well qualified public utility commissioners at high salaries.

An Astounding Economic Blunder That Railroad Executives Would Make

It is reported in the daily press that the Association of Railway Executives intends urging the Interstate Commerce Commission to refuse cars for road building materials, on the ground that highway labor should be diverted to the railway field. It will be a sorry day if the government gives serious ear to any such request. While we recognize the great importance of securing adequate construction and maintenance forces for the railways, it would be an economic error of the first magnitude to divert labor from so important a field as highway construction and maintenance to another field that is scarcely more important. Moreover, it is exceedingly doubtful whether in times of peace the government should undertake to regulate the flow of labor to the various industries. Let the precedent once be established that the government should "ration" the various industries as to labor supply, and there will be no end of foolish meddling. If the railways were to succeed in curtailing road work, as planned, what would prevent the farmers from playing the same game? The farmers could insist with equal logic that freight cars should be diverted from the manufacturers of automobiles to some other industry, so as to force workers in automobile factories to go to the country to find occupation.

The real reason why both railways and farmers are short of labor is their failure to pay high enough wages and furnish attractive enough quarters and surroundings for the workmen. It is sophistical in the extreme to argue that they cannot afford to meet the high wages offered by factories. They certainly cannot afford to do otherwise, in the long run. Moreover, workmen have the right to sell their services to the highest bidder in an open market. This right would be taken from them by the proposed plan to starve out a prospering field of industry by a diversion of freight cars.

We have the utmost sympathy for railway executives, for the railways themselves have been starved for many years, and their present income is insufficient to meet the competition of other industries for labor. But one injustice surely does not call for a remedy in the form of another injustice. One economic blunder cannot be righted by the making of another.

Present Efficiency of Labor

To the Editor: Have just read your interesting study of the "Causes of High Prices." If the 95 per cent of our workers, who are 95 per cent of our consumers, would apply themselves to their daily work in the same spirit that possessed you in writing this, there would be no need or basis for such reasoning.

Some things you say stick in the gullet of my mind and need pepsin in the way of explanation to aid digestion.

You say, 40 per cent to 50 per cent of the total cost of building construction is labor. Our study of total costs in building construction, shows a factor of 80 per cent to 85 per cent labor; that is, commencing at the source of materials in the crude, clay, mines, forests, etc., following the many tangents of production to the final or finished construction. Some items costing more or less, the above being an average.

The above factor is seldom visualized in discussing building costs.

You also say, "The alleged decrease in American efficiency is as a whole imaginary." This is true only when you confine your vision to machinery or mechanical means of production, machinery and standards permitting quantity production is the one element that has saved our hide.

When you visualize the human element of present day labor and compare the quantity and quality efficiency with 20 years or more past, it plainly shows an appalling tax, and in the realm of building industries is the overwhelming cause of higher building costs.

This prompts the belief we have gone too far with either shorter hours and lessened production per man, or both. If everybody laid down on the job and quit producing, it would mean an empty cupboard and stagnation with starvation. There is a limit to short hours and limited production in the man power of this country.

To recapitulate: If labor is the overwhelming cost in the production of material and construction of buildings, is it not reasonable we can reduce costs without cutting the price paid labor, if labor will face the truth, become more efficient in quality and quantity of work delivered for the dollar, at least give a service equal to 20 years ago?

E. A. LAUGHLIN.

Port Arthur, Tex.

[In speaking of the percentage of labor to material costs, it is customary to refer only to a single thing or class of thing. Yet Mr. Laughlin is right in insisting that in the final analysis, much more than 50 per cent of the cost of building is a labor cost. Prof. King, in his "Wealth and Income of the People of the United States," estimates that salaried and wage workers receive about 75 per cent of the total annual income. The remaining 25 per cent goes to capital. The average workman imagines that these per centages are reversed. It is this false belief that probably is at the bottom of much of the present discontent.

We agree with Mr. Laughlin that there is a great deal of loafing on the part of workmen, particularly in the building trades. But we are equally certain that the country as a whole produced as much per capita in 1919 as in 1913, and 10 per cent more per capita than in 1899. It is true that labor saving machinery and methods account for the increase in per capita output, but it is futile to argue that recent high prices are attributable to decreased productivity in America.—Editor.]

Bidding Prices on State Road Work

During April the Department of Public Works of Nebraska sent letters to all of the states requesting information on the bidding prices on various items entering into the building of roads. A summary of the replies is given in the May monthly report of the department, from which the notes following are taken:

STATE OF NEBRASKA.

Earth excavation	$ .58	per cu. yd. average bid prices.
Reinforced concrete headwalls and box culverts	45.56	per cu. yd. in place including back fill and reinforcement.
Concrete pavement 7 in. thick	3.93	per sq. yd.
18 in. concrete pipe	3.06	per lin. ft.-average in place.
18 in. corrugated pipe	2.35	per lin. ft.-average in place.

STATE OF MISSOURI.

Earth excavation	$ .75	
Concrete	2.75	(8 in. in depth, 1 course).

STATE OF IOWA.

Earth excavation	$ .66	per cu. yd. (straight grading).
Earth excavation	1.10	per cu. yd. (for paving).
Concrete paving	4.06	per sq. yd.
Brick paving	5.62	per sq. yd.
18 in. concrete pipe	1.72	per lin. ft.
18 in. corrugated pipe	1.72	per lin. ft.

STATE OF COLORADO.

Earth excavation	$ .285—$1.35	per cu. yd.
Concrete paving	2.59 — 3.17	per sq. yd.
18 in. corrugated pipe	3.75 — 4.10	per foot in place.

STATE OF MICHIGAN.

Earth excavation	$ .70—$1.00	per cu. yd.
Concrete paving	2.70— 3.80	per sq. yd.

No bids awarded in excess of $3.05 per sq. yd.

Bituminous concrete	$3.60—$3.90	per sq. yd.

STATE OF ILLINOIS.

Earth excavation	$ .80	per cu. yd.
Concrete	1.80	per sq. yd. excluding cement.
Brick—on concrete base	3.39	per sq. yd. excluding cement.

STATE OF MINNESOTA.

Earth excavation	$ .55	per cu. yd.
Earth excavation	.65	for per cu. yd. paved road.
Concrete	3.00	per sq. yd. gravel aggregate.
Concrete	3.25	per sq. yd. stone aggregate.
Bithulithic	4.25	per sq. yd.
18 in. concrete pipe	1.55	per lin. ft.
18 in. corrugated pipe	1.92	per lin ft.

No bids on other classes of work.

STATE OF SOUTH DAKOTA.

Earth excavation	$ .60	(highest in 1919).
18 in. corrugated pipe	2.50	installed.

STATE OF OHIO.

Earth excavation	$ .648	per cu. yd. (unclassified).
Plain concrete pavement	2.73	per sq. yd.
Reinforced concrete	3.02	per sq. yd.
Brick on concrete base	3.37	per sq. yd.
Bithulithic on concrete base	4.47	per sq. yd.
Sheet asphalt on concrete base	3.69	per sq. yd.
Bituminous concrete	3.25	per sq. yd.
18 in. concrete pipe in place	3.12	per lin. ft.
18 in. corrugated pipe in place	2.20	per lin. ft.

STATE OF INDIANA.

Earth excavation	$ .94	per cu. yd.
Concrete pavement (6 in. x 8 in.)	1.85	per sq. yd. 18 ft. wide.
Brick on 4 in. concrete base	3.92	per sq. yd.
Bituminous concrete pavement	3.70	per sq. yd. (approaches a sheet asphalt and is laid with 1½ in. top course on a 1 in. binder course with 6 in. base.
18 in. concrete pipe	3.21	per ft.
18 in. corrugated pipe	3.96	per ft.

STATE OF UTAH.

Earth excavation	$ .75	per cu. yd.
Concrete per square yard	1.30	per sq. yd.

STATE OF NEVADA.

Earth excavation	$ .75	per cu. yd.
Concrete	1.00	per sq. yd.
18 in. concrete pipe	3.50	per lin. ft. in place.

STATE OF NEW HAMPSHIRE.

Earth excavation	$1.25—$1.50	per cu. yd.
Asphalt concrete	.90— 2.00	per cu. yd. (termed modified asphalt).
Corrugated pipe	.50— 1.00	per lin. ft. for laying.
	1.80	price per lin. ft. of pipe.

STATE OF VIRGINIA.

Earth excavation	$ .80	per cu. yd.
Concrete	3.15	per sq. yd.
Sheet asphalt on 1-3-6 base	3.20	per sq. yd.
18 in. corrugated pipe in place	2.50	per lin. ft.

STATE OF VERMONT.

Earth excavation	$1.00—$1.50	per cu. yd.
Concrete 6 in.—8 in. thick	2.00— 2.60	per sq. yd. covers expense of laying and no other item of construction.

Cost of Feeding Horses of Cincinnati Street Cleaning Department.—The average cost of feed in 1919 for horses of the street cleaning department of Cincinnati. O., was 63.7 ct. per day per horse. The itemized cost was:

	Per horse, ct.
Hay, 15.6 lb., at $35 per ton	28.37
Oats, 11.7 lb., at 2.4 ct.	27.08
Nutria, 3.3 lb., at 2.5 ct.	8.25
Total	63.7

A New Method for Laying Out Circular Curves by Deflections from the P. I.*

By T. F. HICKERSON,
Associate Professor Civil Engineering, University of North Carolina.

The writer hopes that the tables based upon formulas given below will fill the long-felt need of a simple and time-saving method for laying out circular curves by deflections from the point of intersection of the tangents (the P. I), thus avoiding the trouble of moving the instrument and resetting the vernier.

Referring to Fig. 1, P is any point on the circular arc CB and A is the point of intersection of the tangents. Also C is the point of curve (P. C.), and B is the point of tangent (P. T.). Lines from points A and O to point P make angles of θ and α with the line AO, these angles being plus when measured above AO and minus when below it. PN is drawn perpendicular to AO. The deflection angle is called $\triangle$.

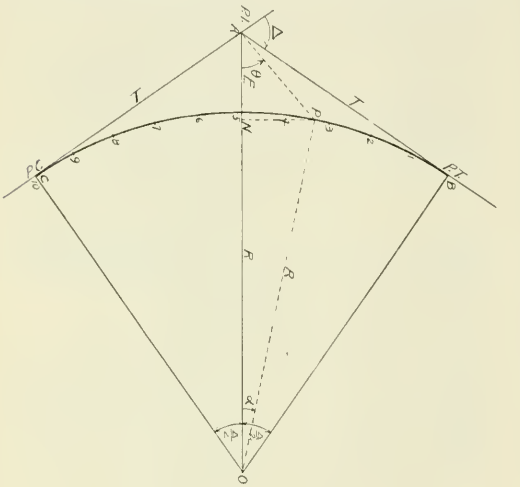

Fig. 1.

$$\operatorname{Tan}\theta = \frac{PN}{AN} = \frac{R\sin\alpha}{E + R - R\cos\alpha} = \frac{R\sin\alpha}{R(\sec\tfrac{1}{2}\triangle - 1) + R - R\cos\alpha}$$

$$\text{Hence,}\quad \tan\theta = \frac{\sin\alpha}{\sec\tfrac{1}{2}\triangle - \cos\alpha} \quad \ldots\ldots\ldots\ldots(1).$$

Formula (1) shows that for a given value of $\triangle$, the angle θ is independent of the radius of the curve or the length of the curve.

Imagine the curve divided into ten equal parts, then formula (1) gives the deflections to these points of division as follows

$$\alpha = 4/10\,\triangle,\ \tan\theta_1 = \frac{\sin 4/10\,\triangle}{\sec\tfrac{1}{2}\triangle - \cos 4/10\,\triangle}$$

$$\alpha = 3/10\,\triangle,\ \tan\theta_2 = \frac{\sin 3/10\,\triangle}{\sec\tfrac{1}{2}\triangle - \cos 3/10\,\triangle}$$

$$\alpha = 2/10\,\triangle,\ \tan\theta_3 = \frac{\sin 2/10\,\triangle}{\sec\tfrac{1}{2}\triangle - \cos 2/10\,\triangle}$$

$$\alpha = 1/10\,\triangle,\ \tan\theta_4 = \frac{\sin 1/10\,\triangle}{\sec\tfrac{1}{2}\triangle - \cos 1/10\,\triangle}$$

$$\alpha = 0 \qquad \theta_5 = 0$$
$$\alpha = -1/10\,\triangle,\ \theta_6 = -\theta_4$$
$$\alpha = -2/10\,\triangle,\ \theta_7 = -\theta_3$$
$$\alpha = -3/10\,\triangle,\ \theta_8 = -\theta_2$$
$$\alpha = -4/10\,\triangle,\ \theta_9 = -\theta_1$$
$$\alpha = -5/10\,\triangle,\ \theta_{10} = -\tfrac{1}{2}(180 - \triangle).$$

Values of θ_1, θ_2, θ_3, etc., computed by means of the above formulas for different values of $\triangle$ show that they change uniformly with $\triangle$; so that interpolation gives results as closely as 1 minute for ranges of 1° in $\triangle$.

For convenience in laying out curves without resetting the vernier, these directions to points on the curve are referred to the first tangent, the line CA produced.

Instrument at the P. I., and vernier reading $\triangle°$ on the P. T., we have:

Deflection to point (1) = $\Delta + \tfrac{1}{2}(180 - \Delta) - \theta_1 = 90° + \tfrac{1}{2}\Delta - \theta_1$,
Deflection to point (2) = $90° + \tfrac{1}{2}\Delta - \theta_2$,
Deflection to point (3) = $90° + \tfrac{1}{2}\Delta - \theta_3$,
Deflection to point (4) = $90° + \tfrac{1}{2}\Delta - \theta_4$,
Deflection to point (5) = $90° + \tfrac{1}{2}\Delta$,
Deflection to point (6) = $90° + \tfrac{1}{2}\Delta + \theta_4$,
Deflection to point (7) = $90° + \tfrac{1}{2}\Delta + \theta_3$,
Deflection to point (8) = $90° + \tfrac{1}{2}\Delta + \theta_2$,
Deflection to point (9) = $90° + \tfrac{1}{2}\Delta + \theta_1$,
Deflection to point (10) = 180°.

It should be noted that the following pairs of deflections add up to 180° + $\triangle$; (1) + (9), (2) + (8), (3) + (7) and (4) + (6).

Using the above formulas, tables have been computed for all values of the deflection angle $\triangle$ varying by 1° from 3° to 128°. This covers all cases that are likely to occur in locating curves for roads and streets.

Figure 2 is a graphical verification of the fact that for a fixed $\triangle$, the deflections to points of equal division on a curve remain constant for any length of the curve. This makes the method perfectly general.

The order of procedure in laying out a curve is as follows: (1) set up the instrument at the P.I., backsight on the first tangent with vernier reading 0°, transit the telescope, unclamp the vernier and fix the line of sight on the second tangent, the vernier giving the deflection angle $\triangle°$; (2) decide what length of curve to use (determined usually either by the desired external distance E or the tangent length (T; (3) compute T and E, using either the well known tables of tangents and externals for a 1° curve, or preferably the tangents and externals for a 100 ft. curve Table (II); (4) lay off the tangent length locating the end of the curve (the P. T.); (5) divide the length of curve by 10 and locate each of the ten points, or every other one, or every third one, etc., depending upon how many are needed to properly define the curve, by starting at the P.T., and getting the intersection of the end of the chord with the line of sight from the P.I., according to deflections read directly from the tables (Table I).

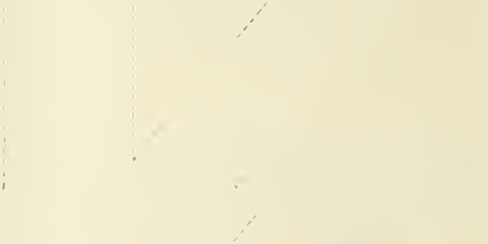

Fig. 2.

The middle point, or the 5th point of the curve, cannot be located very precisely by intersections, since the end of the chord would be moved in an arc tangent to the line of sight. This point can be located exactly by measuring the external distance E from the P.I., and this serves as a check. If only the 2nd, 4th, 6th, 8th, and 10th points are located, then it is not necessary to know E.

The beginning of the curve (the P.C.) is located as the 10th point by a deflection which is always 180°. The station num-

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TABLE I- DEFLECTIONS FROM THE P.I. TO POINTS OF EQUAL DIVISION

ALONG CIRCULAR CURVES.

Pts.	Δ = 3°00'	Diff. 1'	Δ = 3°30'	Diff. 1'	Δ = 4°00'	Diff. 1'	Δ = 4°30'	Diff. 1'	Δ = 5°00'	Diff. 1'	Δ = 5°30'	Diff. 1'	Δ = 6°00'	Diff. 1'	Δ = 6°30'	Diff. 1'	Δ = 7°00'	Diff. 1'
1-	3°02'	+1.00'	3°33'	+1.00'	4°03'	+1.00'	4°35'	+1.00'	5°04'	+1.00'	5°34'	+1.00'	6°04'	+1.00'	6°35'	+1.00'	7°05'	+1.00'
2-	3°11'	+1.13'	3°46'	+1.03'	4°16'	+1.06'	4°48'	+1.03'	5°19'	+1.07'	5°51'	+1.07'	6°23'	+1.07'	6°56'	+1.07'	7°28'	+1.07'
3-	3°38'	+1.30'	4°17'	+1.27'	4°55'	+1.17'	5°30'	+1.20'	6°06'	+1.22'	6°43'	+1.22'	7°20'	+1.22'	7°57'	+1.22'	8°34'	+1.22'
4-	5°19'	+2.07'	6°21'	+1.83'	7°10'	+1.80'	8°04'	+1.80'	8°58'	+1.81'	9°52'	+1.70'	10°43'	+1.81'	11°38'	+1.78'	12°31'	+1.88'
5-	91°30'	+0.50'	91°45'	+0.50'	92°00'	+0.50'	92°15'	+0.50'	92°30'	+0.50'	92°45'	+0.50'	93°00'	+0.50'	93°15'	+0.50'	93°30'	+0.50'
6-	177°41'	-1.07'	179°09'	-0.63'	176°50'	-0.80'	176°25'	-0.80'	176°02'	-0.81'	175°38'	-0.70'	175°17'	-0.81'	174°52'	-0.78'	174°29'	-0.88'
7-	179°22'	-0.30'	179°13'	-0.27'	179°05'	-0.17'	179°00'	-0.20'	178°54'	-0.22'	178°47'	-0.22'	178°40'	-0.22'	178°33'	-0.22'	178°28'	-0.22'
8-	179°49'	-0.13'	179°45'	-0.03'	179°44'	-0.06'	179°42'	-0.03'	179°41'	-0.07'	179°39'	-0.07'	179°37'	-0.07'	179°34'	-0.07'	179°32'	-0.07'
9-	179°58'	-0.00'	179°57'	-0.00'	179°57'	-0.00'	179°57'	-0.00'	179°56'	-0.00'	179°56'	-0.00'	179°56'	-0.00'	179°55'	-0.00'	179°55'	-0.00'
10-	180°00'	0.00'	180°00'	0.00'	180°00'	0.00'	180°00'	0.00'	180°00'	0.00'	180°00'	0.00'	180°00'	0.00'	180°00'	0.00'	180°00'	0.00'

Pts.	Δ = 7°30'	Diff. 1'	Δ = 8°00'	Diff. 1'	Δ = 8°30'	Diff. 1'	Δ = 9°00'	Diff. 1'	Δ = 9°30'	Diff. 1'	Δ = 10°00'	Diff. 1'	Δ = 10°30'	Diff. 1'	Δ = 11°00'	Diff. 1'	Δ = 11°30'	Diff. 1'
1-	7°36'	+1.00'	8°06'	+1.00'	8°36'	+1.00'	9°07'	+1.00'	9°37'	+1.00'	10°08'	+1.00'	10°38'	+1.00'	11°08'	+1.00'	11°39'	+1.00'
2-	8°00'	+1.07'	8°32'	+1.07'	9°04'	+1.07'	9°36'	+1.06'	10°08'	+1.06'	10°40'	+1.06'	11°12'	+1.06'	11°44'	+1.06'	12°16'	+1.06'
3-	9°10'	+1.22'	9°47'	+1.22'	10°24'	+1.22'	11°01'	+1.22'	11°37'	+1.22'	12°14'	+1.22'	12°51'	+1.22'	13°27'	+1.22'	14°04'	+1.22'
4-	13°28'	+1.70'	14°19'	+1.78'	15°12'	+1.69'	16°03'	+1.83'	16°58'	+1.70'	17°49'	+1.76'	18°42'	+1.74'	19°34'	+1.74'	20°26'	+1.73'
5-	93°45'	+0.50'	94°00'	+0.50'	94°15'	+0.50'	94°30'	+0.50'	94°45'	+0.50'	95°00'	+0.50'	94°15'	+0.50'	94°30'	+0.50'	94°45'	+0.50'
6-	174°02'	-0.70'	173°41'	-0.78'	173°18'	-0.69'	172°57'	-0.83'	172°32'	-0.70'	172°11'	-0.76'	171°48'	-0.74'	171°26'	-0.74'	171°04'	-0.75'
7-	178°19'	-0.22'	178°12'	-0.22'	178°05'	-0.22'	177°59'	-0.22'	177°53'	-0.22'	177°46'	-0.22'	177°39'	-0.22'	177°33'	-0.22'	177°26'	-0.22'
8-	179°30'	-0.07'	179°28'	-0.07'	179°26'	-0.07'	179°24'	-0.06'	179°22'	-0.06'	179°20'	-0.06'	179°18'	-0.06'	179°16'	-0.06'	179°14'	-0.06'
9-	179°54'	-0.00'	179°54'	-0.00'	179°54'	-0.00'	179°53'	-0.00'	179°53'	-0,00'	179°52'	-0.00'	179°52'	-0.00'	179°52'	-0.00'	179°51'	-0.00'
10-	180°00'	0.00	180°00'	0.00'	180°00'	0.00	180°00'	0.00'	180°00'	0,00'	180°00'	0.00'	180°00'	0.00'	180°00'	0.00'	180°00'	0.00'

Pts.	Δ = 12°00'	Diff. 1'	Δ = 12°30'	Diff. 1'	Δ = 13°00'	Diff. 1'	Δ = 14°	Diff. 1'	Δ = 15°	Diff. 1'	Δ = 16°	Diff. 1'	Δ = 17°	Diff. 1'	Δ = 18°	Diff. 1'	Δ = 19°	Diff. 1'
1-	12°09'	+1.00'	12°39'	+1.00'	13°10'	+1.01'	14°10'	+1.01'	15°11'	+1.01'	16°12'	+1.01'	17°13'	+1.01'	18°13'	+1.01'	19°14'	+1.01'
2-	12°48'	+1.06'	13°20'	+1.06'	13°51'	+1.06'	14°55'	+1.06'	15°59'	+1.06'	17°03'	+1.06'	18°07'	+1.06'	19°11'	+1.06'	20°15'	+1.06'
3-	14°41'	+1.22'	14°17'	+1.22'	15°53'	+1.21'	17°05'	+1.21'	18°19'	+1.21'	19°32'	+1.21'	20°44'	+1.21'	21°57'	+1.21'	23°10'	+1.21'
4-	21°18'	+1.73'	22°10'	+1.71'	23°01'	+1.71'	24°44'	+1.69'	26°35'	+1.69'	28°05'	+1.67'	29°46'	+1.66'	31°25'	+1.64'	33°04'	+1.62'
5-	96°00'	+0.50'	96°15'	+0.50'	96°30'	+0.50'	97°00'	+0.50'	97°30'	+0.50'	98°00'	+0.50'	98°30'	+0.50'	99°00'	+0.50'	99°30'	+0.50'
6-	170°42'	-0.73'	170°20'	-0.71'	169°59'	-0.71'	169°16'	-0.69'	168°32'	-0.69'	167°54'	-0.67'	167°14'	-0.66'	166°35'	-0.64'	165°55'	-0.62'
7-	177°19'	-0.22'	177°13'	-0.22'	177°07'	-0.21'	176°54'	-0.21'	176°41'	-0.21'	176°28'	-0.21'	176°16'	-0.21'	176°03'	-0.21'	175°50'	-0.21'
8-	179°12'	-0.06'	179°10'	-0.06'	179°09'	-0.06'	179°05'	-0.06'	179°01'	-0.06'	178°57'	-0.06'	178°53'	-0.06'	178°49'	-0.06'	178°45'	-0.06'
9-	179°51'	-0.00'	179°51'	-0.00'	179°50'	-0.01'	179°50'	-0.01'	179°49'	-0.01'	179°48'	-0.01'	179°47'	-0.01'	179°47'	-0.01'	179°46'	-0.01'
10-	180°00'	0.00	180°00'	0.00'	180°00'	0.00'	180°00'	0.00'	180°00'	0.00'	180°00'	0.00'	180°00'	0.00'	180°00'	0.00'	180°00'	0.00'

Pts.	Δ = 20°	Diff. 1'	Δ = 21°	Diff. 1'	Δ = 22°	Diff. 1'	Δ = 23°	Diff. 1'	Δ = 24°	Diff. 1'	Δ = 25°	Diff. 1'	Δ = 26°	Diff. 1'	Δ = 27°	Diff. 1'	Δ = 28°	Diff. 1'
1-	20°15'	+1.01'	21°16'	+1.01'	22°16'	+1.01'	23°17'	+1.01'	24°18'	+1.01'	25°18'	+1.01'	26°19'	+1.01'	27°20'	+1.01'	28°20'	+1.01'
2-	21°19'	+1.06'	22°22'	+1.06'	23°25'	+1.06'	24°30'	+1.06'	25°33'	+1.06'	26°37'	+1.06'	27°41'	+1.06'	28°[illegible]	+1.06'	29°48'	+1.05'
3-	24°22'	+1.20'	25°34'	+1.20'	26°46'	+1.20'	27°58'	+1.20'	29°10'	+1.20'	30°22'	+1.19'	31°33'	+1.19'	32°44'	+1.19'	33°55'	+1.19'
4-	34°41'	+1.60'	35°17'	+1.60'	37°53'	+1.57'	39°27'	+1.55'	41°00'	+1.54'	42°35'	+1.52'	44°04'	+1.51'	45°35'	+1.48'	47°04'	+1.48'
5-	100°00'	+0.50'	100°30'	+0.50'	101°00'	+0.50'	101°30'	+0.50'	102°00'	+0.50'	102°30'	+0.50'	103°00'	+0.50'	103°30'	+0.50'	104°00'	+0.50'
6-	165°19'	-0.60'	164°43'	-0.60'	164°07'	-0.57'	163°33'	-0.55'	162°60'	-0.54'	162°27'	-0.52'	161°55'	-0.51'	161°25'	-0.48'	160°56'	-0.48'
7-	175°38'	-0.20'	175°26'	-0.20'	175°14'	-0.20'	175°02'	-0.20'	174°50'	-0.20'	174°38'	-0.19'	174°27'	-0.19'	174°16'	-0.19'	174°04'	-0.19'
8-	178°41'	-0.05'	178°38'	-0.06'	178°34'	-0.06'	178°30'	-0.06'	178°26'	-0.06'	178°23'	-0.06'	178°19'	-0.06'	178°15'	-0.06'	178°12'	-0.06'
9-	179°45'	-0.01'	179°44'	-0.01'	179°44'	-0.01'	179°43'	-0.01'	179°42'	-0.01'	179°42'	-0.01'	179°41'	-0.01'	179°40	-0.01'	179°40'	-0.01'
10-	180°00'	0.00'	180°00'	0.00'	180°00'	0.00'	180°00'	0.00'	180°00'	0.00'	180°00'	0.00'	180°00'	0.00'	180°00'	0.00'	180°00'	0.00'

[illegible] FROM THE P.I. TO POINTS OF EQUAL DIVISION

ALONG CIRCULAR CURVES.

Pts.	Δ = 29°	Diff. 1'	Δ = 30°	Diff. 1'	Δ = 31°	Diff. 1'	Δ = 32°	Diff. 1'	Δ = 33°	Diff. 1'	Δ = 34°	Diff. 1'	Δ = 35°	Diff. 1'	Δ = 36°	Diff. 1'	Δ = 37°	Diff. 1'
1-	29°21'	+1.01'	30°22'	+1.01'	31°23'	+1.01'	32°23'	+1.01'	33°24'	+1.01'	34°24'	+1.01'	35°25'	+1.01'	36°26'	+1.01'	37°26'	+1.01'
2-	30°52'	+1.05'	31°55'	+1.05'	32°59'	+1.06'	34°02'	+1.06'	35°06'	+1.06'	36°09'	+1.05'	37°13'	+1.05'	38°16'	+1.06'	39°19'	+1.06'
3-	35°07'	+1.19'	36°18'	+1.18'	37°29'	+1.18'	38°39'	+1.17'	39°49'	+1.17'	41°00'	+1.17'	42°10'	+1.17'	43°20'	+1.17'	44°30'	+1.16'
4-	48°33'	+1.46'	50°00'	+1.44'	51°25'	+1.43'	52°52'	+1.41'	54°17'	+1.39'	55°40'	+1.38'	57°03'	+1.35'	58°24'	+1.34'	59°44'	+1.33'
5-	104°30'	+0.50'	105°00'	+0.50'	105°30'	+0.50'	106°00'	+0.50'	106°30'	+0.50'	107°00'	+0.50'	107°30'	+0.50'	108°00'	+0.50'	108°30'	+0.50'
6-	160°27'	-0.45'	160°00'	-0.44'	159°34'	-0.43'	159°08'	-0.41'	158°43'	-0.39'	158°20'	-0.38'	157°57'	-0.35'	157°36'	-0.34'	157°16'	-0.33'
7-	173°53'	-0.19'	173°42'	-0.18'	173°31'	-0.18'	173°21'	-0.17'	173°11'	-0.17'	173°00'	-0.17'	172°50'	-0.17'	172°40'	-0.17'	172°30'	-0.16'
8-	178°08'	-0.05'	178°05'	-0.06'	178°01'	-0.06'	177°58'	-0.05'	177°54'	-0.06'	177°51'	-0.06'	177°47'	-0.06'	177°44'	-0.06'	177°41'	-0.06'
9-	179°39'	-0.01'	179°38'	-0.01'	179°37'	-0.01'	179°37'	-0.01'	179°36'	-0.01'	179°36'	-0.01'	179°35'	-0.01'	179°34'	-0.01'	179°34'	-0.01'
10-	180°00'	0.00'	180°00'	0.00'	180°00'	0.00'	180°00'	0.00'	180°00'	0.00'	180°00'	0.00'	180°00'	0.00'	180°00'	0.00'	180°00'	0.00'

Pts.	Δ = 38°	Diff. 1'	Δ = 39°	Diff. 1'	Δ = 40°	Diff. 1'	Δ = 41°	Diff. 1'	Δ = 42°	Diff. 1'	Δ = 43°	Diff. 1'	Δ = 44°	Diff. 1'	Δ = 45°	Diff. 1'	Δ = 46°	Diff. 1'
1-	38°27'	+1.01'	39°28'	+1.01'	40°29'	+1.01'	41°29'	+1.01'	42°30'	+1.01'	43°30'	+1.01'	44°31'	+1.01'	45°32'	+1001'	46°32'	+1.01'
2-	40°22'	+1.05'	41°26'	+1.05'	42°29'	+1.05'	43°32'	+1.06'	44°35'	+1005'	45°38'	+1.05'	46°41'	+1.05'	47°44'	+1.05'	48°47'	+1.05'
3-	45°39'	+1.16'	46°49'	+1.15'	47°58'	+1.15'	49°07'	+1.15'	50°16'	+1.15'	51°25'	+1.14'	52°33'	+1.14'	53°41'	+1.14'	54°49'	+1.13'
4-	61°04'	+1.31'	62°23'	+1.30'	63°41'	+1.28'	64°58'	+1.27'	66°14'	+1.25'	67°29'	+1.24'	68°43'	+1.23'	69°57'	+1.21'	71°10'	+1.20'
5-	109°00'	+0.50'	109°30'	+0.50'	110°00'	+0.50'	110°30'	+0.50'	111°00'	+0.50'	111°30'	+0.50'	112°00'	+0.50'	112°30'	+0.50'	113°00'	+0.50'
6-	155°56'	-0.31'	155°37'	-0.30'	155°19'	-0.28'	155°02'	-0.27'	155°45'	-0.25'	155°31'	-0.24'	155°17'	-0.23'	155°03'	-0.21'	154°50'	-0.20'
7-	172°21'	-0.15'	172°11'	-0.15'	172°02'	-0.15'	171°53'	-0.15'	171°44'	-0.15'	171°35'	-0.14'	171°27'	-0.14'	171°19'	-0.14'	171°11'	-0.13'
8-	177°38'	-0.05'	177°34'	-0.05'	177°31'	-0.05'	177°28'	-0.05'	177°25'	-0.05'	177°22'	-0.05'	177°19'	-0.05'	177°16'	-0.05'	177°13'	-0.05'
9-	179°33'	-0.01'	179°32'	-0.01'	179°31'	-0.01'	179°31'	-0.01'	179°30'	-0.01'	179°30'	-0.01'	179°29'	-0.01'	179°28'	-0.01'	179°28'	-0.01'
10-	180°00'	0.00'	180°00'	0.00'	180°00'	0.00'	180°00'	0.00'	180°00'	0.00'	180°00'	0.00'	180°00'	0.00'	180°00'	0.00'	180°00'	0.00'

Pts.	Δ = 47°	Diff. 1'	Δ = 48°	Diff. 1'	Δ = 49°	Diff. 1'	Δ = 50°	Diff. 1'	Δ = 51°	Diff. 1'	Δ = 52°	Diff. 1'	Δ = 53°	Diff. 1'	Δ = 54°	Diff. 1'	Δ = 55°	Diff. 1'
1-	47°33'	+1.01'	48°33'	+1.01'	49°34'	+1.01'	50°34'	+1.01'	51°35'	+1.01'	52°36'	+1.01'	53°36'	+1.01'	54°37'	+1.01'	55°37'	+1.01'
2-	49°50'	+1.05'	50°53'	+1.05'	51°55'	+1.05'	52°58'	+1.05'	54°01'	+1.04'	55°04'	+1.04'	56°06'	+1.04'	57°09'	+1.04'	58°11'	+1.04'
3-	55°57'	+1.13'	57°05'	+1.12'	58°12'	+1.12'	59°19'	+1.12'	60°26'	+1.11'	61°33'	+1.11'	62°40'	+1.11'	63°46'	+1.10'	64°53'	+1.10'
4-	72°22'	+1.18'	73°33'	+1.17'	74°43'	+1.16'	75°53'	+1.15'	77°02'	+1.14'	78°10'	+1.13'	79°18'	+1.12'	80°25'	+1.10'	81°31'	+1.09'
5-	113°30'	+0.50'	114°00'	+0.50'	114°30'	+0.50'	115°00'	+0.50'	115°30'	+0.50'	116°00'	+0.50'	116°30'	+0.50'	117°00'	+0.50'	117°30'	+0.50'
6-	154°38'	-0.18'	154°27'	-0.17'	154°17'	-0.16'	154°07'	-0.15'	153°58'	-0.14'	153°50'	-0.13'	153°42'	-0.12'	153°35'	-0.10'	153°29'	-0.09'
7-	171°03'	-0.13'	170°55'	-0.13'	170°48'	-0.12'	170°41'	-0.12'	170°34'	-0.11'	170°27'	-0.11'	170°20'	-0.11'	170°14'	-0.10'	170°07'	-0.10'
8-	177°10'	-0.05'	177°07'	-0.05'	177°05'	-0.05'	177°02'	-0.05'	176°59'	-0.04'	176°56'	-0.04'	176°54'	-0.04'	176°51'	-0.04'	176°49'	-0.04'
9-	179°27'	-0.01'	179°27'	-0.01'	179°26'	-0.01'	179°25'	-0.01'	179°25'	-0.01'	179°24'	-0.01'	179°24'	-0.01'	179°23'	-0.01'	179°23'	-0.01'
10-	180°00'	0.00'	180°00'	0.00'	180°00'	0.00'	180°00'	0.00'	180°00'	0.00'	180°00'	0.00'	180°00'	0.00'	180°00'	0.00'	180°00'	0.00'

Pts.	Δ = 56°	Diff. 1'	Δ = 57°	Diff. 1'	Δ = 58°	Diff. 1'	Δ = 59°	Diff. 1'	Δ = 60°	Diff. 1'	Δ = 61°	Diff. 1'	Δ = 62°	Diff. 1'	Δ = 63°	Diff. 1'	Δ = 64°	Diff. 1'
1-	56°38'	+1.01'	57°38'	+1.01'	58°39'	+1.01'	59°39'	+1.01'	60°40'	+1.01'	61°40'	+1.01'	62°41'	+1.01'	63°41'	+1.01'	64°42'	+1.01'
2-	59°14'	+1.04'	60°16'	+1.04'	61°18'	+1.04'	62°21'	+1.04'	63°23'	+1.03'	64°25'	+1.03'	65°27'	+1.03'	66°29'	+1.03'	67°32'	+1.03'
3-	65°59'	+1.10'	67°04'	+1.09'	68°10'	+1.09'	69°15'	+1.09'	70°20'	+1.08'	71°25'	+1.08'	72°30'	+1.07'	73°34'	+1.07'	74°39'	+1.07'
4-	82°35'	+1.08'	83°41'	+1.07'	84°45'	+1.07'	85°49'	+1.05'	86°52'	+1.04'	87°55'	+1.03'	88°57'	+1.03'	89°58'	+1.01'	90°59'	+1.01'
5-	118°00'	+0.50'	118°30'	+0.50'	119°00'	+0.50'	119°30'	+0.50'	120°00'	+0.50'	120°30'	+0.50'	121°00'	+0.50'	121°30'	+0.50'	122°00'	+0.50'
6-	153°24'	-0.08'	153°19'	-0.07'	153°15'	-0.07'	153°11'	-0.05'	153°08'	-0.04'	153°05'	-0.05'	153°03'	-0.03'	153°02'	-0.01'	153°01'	-0.01'
7-	170°01'	-0.10'	169°55'	-0.09'	169°50'	-0.09'	169°45'	-0.09'	169°40'	-0.08'	169°35'	-0.08'	169°30'	-0.07'	169°26'	-0.07'	169°21'	-0.07'
8-	176°45'	-0.04'	176°44'	-0.04'	176°42'	-0.04'	176°39'	-0.04'	176°37'	-0.03'	176°35'	-0.03'	176°33'	-0.03'	176°31'	-0.03'	176°28'	-0.03'
9-	179°22'	-0.01'	179°22'	-0.01'	179°21'	-0.01'	179°21'	-0.01'	179°20'	-0.01'	179°20'	-0.01'	179°19'	-0.01'	179°19'	-0.01'	179°18'	-0.01'
10-	180°00'	0.00'	180°00'	0.00'	180°00'	0.00'	180°00'	0.00'	180°00'	0.00'	180°00'	0.00'	180°00'	0.00'	180°00'	0.00'	180°00'	0.00'

TABLE I- DEFLECTIONS FROM THE P.I. TO POINTS OF EQUAL DIVISION

ALONG CIRCULAR CURVES.

Pts.	Δ = 65°	Diff. 1'	Δ = 66°	Diff. 1'	Δ = 67°	Diff. 1'	Δ = 68°	Diff. 1'	Δ = 69°	Diff. 1'	Δ = 70°	Diff. 1'	Δ = 71°	Diff. 1'	Δ = 72°	Diff. 1'	Δ = 73°	Diff. 1'
1-	65°42'	+1.01'	66°43'	+1.01'	67°43'	+1.01'	68°44'	+1.01	69°44'	+1.01'	70°44'	+1.01'	71°45'	+1.01'	72°46'	+1.01'	73°46'	+1.01'
2-	68°34'	+1.03'	69°35'	+1.03'	70°37'	+1.03'	71°39'	+1.03'	72°41'	+1.03'	73°42'	+1.03'	74°44'	+1.03'	75°46'	+1.02'	76°47'	+1.02'
3-	75°42'	+1.06'	76°46'	+1106'	77°50'	+1.06'	78°53'	+1.06'	79°57'	+1.05'	81°00'	+1.05'	82°03'	+1.04'	83°05'	+1.04'	84°08'	+1.04'
4-	91°59'	+1.00'	92°59'	+0.99'	93°59'	+0.98'	94°58'	+0.97'	95°56'	+0.96'	96°54'	+0.96'	97°51'	+0.95'	98°49'	+0.94'	99°45'	+0.94'
5-	122°30'	+0.50'	123°00'	+0.50'	123°30'	+0.50'	124°00'	+0.50'	124°30'	+0.50'	125°00'	+0.50'	125°30'	+0.50'	126°00'	+0.50'	126°30'	+0.50'
6-	153°00'	+0.00'	153°01'	+0.01'	153°01'	+0.02'	153°02'	+0.03'	153°04'	+0.04'	153°06'	+0.04'	153°08'	+0.05'	153°11'	+0.06'	153°15'	+0.06'
7-	169°17'	-0.06'	169°14'	-0.06'	169°10'	-0.06'	169°07'	-0.05'	169°03'	-0.05'	169°00'	-0.05'	168°57'	-0.04'	168°55'	-0.04'	168°52'	-0.04'
8-	176°28'	-0.03'	176°25'	-0.03'	176°23'	-0.03'	176°21'	-0.03'	176°19'	-0.03'	176°18'	-0.03'	176°16'	-0.03'	176°14'	-0.02'	176°13'	-0.02'
9-	179°18'	-0.01'	179°17'	-0.01'	179°17'	-0.01'	179°16'	-0.01'	179°16'	-0.01'	179°16'	-0.01'	179°15'	-0.01'	179°15'	-0.01'	179°15'	-0.01'
10-	180°00'	0.00'	180°00'	0.00'	180°00'	0.00'	180°00'	0.00'	180°00'	0.00'	180°00'	0.00'	180°00'	0.00'	180°00'	0.00'	180°00'	0.00'

Pts.	Δ = 74°	Diff. 1'	Δ = 75°	Diff. 1'	Δ = 76°	Diff. 1'	Δ = 77°	Diff. 1'	Δ = 78°	Diff. 1'	Δ = 79°	Diff. 1'	Δ = 80°	Diff. 1'	Δ = 81°	Diff. 1'	Δ = 82°	Diff. 1'
1-	74°46'	+1.01'	75°46'	+1.01'	76°47'	+1.00'	77°47'	+1.01'	78°47'	+1.01'	79°47'	+1.01'	80°48'	+1.01'	81°48'	+1.00'	82°48'	+1.00'
2-	77°49'	+1.02'	78°50'	+1.02'	79°51'	+1.02'	80°52'	+1.02'	81°54'	+1.02'	81°55'	+1.02'	81°56'	+1.02'	84°57'	+1.02'	85°58'	+1.01'
3-	85°10'	+1.03'	86°12'	+1.03'	87°14'	+1.02'	88°15'	+1.02'	89°16'	+1.02'	90°18'	+1.02'	91°19'	+1.01'	92°19'	+1.01'	93°20'	+1.01'
4-	100°41'	+0.93'	101°37'	+0.92'	102°32'	+0.92'	103°28'	+0.91'	104°22'	+0.91'	105°17'	+0.90'	106°10'	+0.89'	107°04'	+0.88'	107°57'	+0.88'
5-	127°00'	+0.50'	127°30'	+0.50'	128°00'	+0.50'	128°30'	+0.50'	129°00'	+0.50'	129°30'	+0.50'	130°00'	+0.50'	130°30'	+0.50'	131°00'	+0.50'
6-	153°19'	+0.07'	153°23'	+0.08'	153°28'	+0.08'	153°32'	+0.09'	153°38'	+0.09'	153°43'	+0.10'	153°50'	+0.11'	153°56'	+0.12'	154°03'	+0.12'
7-	168°50'	-0.03'	168°48'	-0.03'	168°46'	-0.02'	168°45'	-0.02'	168°44'	-0.02'	168°42'	-0.02'	168°41'	-0.01'	168°41'	-0.01'	168°40'	-0.01'
8-	176°11'	-0.02'	176°10'	-0.02'	176°09'	-0.02'	176°08'	-0.02'	176°06'	-0.02'	176°05'	-0.02'	176°04'	-0.02'	176°03'	-0.01'	176°02'	-0.01'
9-	179°14'	-0.01'	179°14'	-0.01'	179°13'	-0.00'	179°13'	-0.01'	179°13'	-0.01'	179°13'	-0.01'	179°12'	-0.01'	179°12'	-0.00'	179°12'	-0.00'
10-	180°00'	0.00'	180°00'	0.00'	180°00'	0.00'	180°00'	0.00'	180°00'	0.00'	180°00'	0.00'	180°00'	0.00'	180°00'	0.00'	180°00'	0.00'

Pts.	Δ = 83°	Diff. 1'	Δ = 84°	Diff. 1'	Δ = 85°	Diff. 1'	Δ = 86°	Diff. 1'	Δ = 87°	Diff. 1'	Δ = 88°	Diff. 1'	Δ = 89°	Diff. 1'	Δ = 90°	Diff. 1'	Δ = 91°	Diff. 1'
1-	83°49'	+1.00'	84°49'	+1.00'	85°49'	+1.00	86°49'	+1.00'	87°50'	+1.00'	88°50'	+1.00'	89°50'	+1.00'	90°50'	+1.00'	91°50'	+1.00'
2-	86°59'	+1.01'	87°59'	+1.01'	89°00'	+1.01'	90°01'	+1.01'	91°01'	+1.01'	92°02'	+1.01'	93°03'	+1.01'	94°03'	+1.01'	95°03'	+1.00'
3-	94°20'	+1.00'	95°20'	+1.00'	96°20'	+1.00'	97°20'	+0.99'	98°20'	+0.99'	99°19'	+0.99'	100°18'	+0.98'	101°17'	+0.98'	102°16'	+0.98'
4-	108°50'	+0.88'	109°48'	+0.87'	110°35'	+0.87'	111°27'	+0.86'	112°18'	+0.85'	113°10'	+0.86'	114°01'	+0.85'	114°52'	+0.84'	115°42'	+0.84'
5-	131°30'	+0.50'	132°00'	+0.50'	132°30'	+0.50'	133°00'	+0.50'	133°30'	+0.50'	134°00'	+0.50'	134°30'	+0.50'	135°00'	+0.50'	135°30'	+0.50'
6-	154°10'	+0.12'	154°17'	+0.13'	154°25'	+0.13'	154°33'	+0.14'	154°42'	+0.15'	154°50'	+0.15'	154°59'	+0.15'	155°08'	+0.16'	155°18'	+0.18'
7-	168°40'	-0.00'	168°40'	-0.00'	168°40'	+0.00'	168°40'	+0.01'	168°40'	+0.01'	168°41'	+0.01'	168°42'	+0.02'	168°43'	+0.02'	168°44'	+0.02'
8-	176°01'	-0.01'	176°01'	-0.01'	176°00'	-0.01'	175°59'	-0.01'	175°59'	-0.01'	175°58'	-0.01'	175°57'	-0.01'	175°57'	-0.01'	175°57'	-0.00'
9-	179°11'	-0.00'	179°11'	-0.00'	179°11'	-0.00'	179°11'	-0.00'	179°10'	-0.00'	179°10'	-0.00'	179°10'	-0.00'	179°10'	-0.00'	179°10'	-0.00'
10-	180°00'	0.00'	180°00'	0.00'	180°00'	0.00'	180°00'	0.00'	180°00'	0.00'	180°00'	0.00'	180°00'	0.00'	180°00'	0.00'	180°00'	0.00'

Pts.	Δ = 92°	Diff. 1'	Δ = 93°	Diff. 1'	Δ = 94°	Diff. 1'	Δ = 95°	Diff. 1'	Δ = 96°	Diff. 1'	Δ = 97°	Diff. 1'	Δ = 98°	Diff. 1'	Δ = 99°	Diff. 1'	Δ = 100°	Diff. 1'
1-	92°51'	+1.00'	93°51'	+1.00'	94°51'	+1.00'	95°51'	+1.00'	96°51'	+1.00'	97°51'	+1.00'	98°51'	+1.00'	99°51'	+1.00'	100°51'	+1.00'
2-	96°04'	+1.00'	97°04'	+1.00'	98°04'	+1.00'	99°04'	+1.00'	100°04'	+1.00'	101°04'	+1.00'	102°04'	+1.00'	103°04'	+1.00'	104°04'	+1.00'
3-	103°15'	+0.98'	104°13'	+0.97'	105°12'	+0.97'	106°10'	+0.97'	107°08'	+0.96'	108°03'	+0.96'	109°03'	+0.96'	110°01'	+0.95'	110°58'	+0.95'
4-	116°32'	+0.83'	117°22'	+0.83'	118°12'	+0.82'	119°01'	+0.82'	119°50'	+0.82'	120°40'	+0.81'	121°28'	+0.81'	122°17'	+0.80'	123°05'	+0.80'
5-	136°00'	+0.50'	136°30'	+0.50'	137°00'	+0.50'	137°30'	+0.50'	138°00'	+0.50'	138°30'	+0.50'	139°00'	+0.50'	139°30'	+0.50'	140°00'	+0.50'
6-	155°28'	+0.17'	155°38'	+0.17'	155°48'	+0.18'	155°59'	+0.18'	156°10'	+0.18'	156°20'	+0.19'	156°32'	+0.19'	156°43'	+0.20'	156°55'	+0.20'
7-	168°45'	+0.02'	168°47'	+0.03'	168°48'	+0.03'	168°50'	+0.03'	168°52'	+0.04'	168°56'	+0.04'	168°57'	+0.04'	168°59'	+0.05'	169°02'	+0.05'
8-	175°56'	-0.00'	175°56'	-0.00'	175°56'	-0.00'	175°56'	0.00'	175°56'	+0.00'	175°56'	+0.00'	175°56'	+0.00'	175°56'	+0.00'	175°56'	+0.00'
9-	179°09'	-0.00'	179°09'	-0.00'	179°09'	-0.00'	179°09'	-0.00'	179°09'	-0.00'	179°09'	-0.00'	179°09'	-0.00'	179°09'	-0.00'	179°09'	-0.00'
10-	180°00'	0.00'	180°00'	0.00'	180°00'	0.00'	180°00'	0.00'	180°00'	0.00'	180°00'	0.00'	180°00'	0.00'	180°00'	0.00'	180°00'	0.00'

TABLE I- DEFLECTIONS FROM THE P.I. TO POINTS OF EQUAL DIVISION

ALONG CIRCULAR CURVES.

Pts.	Δ = 101°	Diff. 1'	Δ = 102°	Diff. 1'	Δ = 103°	Diff. 1'	Δ = 104°	Diff. 1'	Δ = 105°	Diff. 1'	Δ = 106°	Diff. 1'	Δ = 107°	Diff. 1'	Δ = 108°	Diff. 1'	Δ = 109°	Diff. 1'
1-	101°51'	+1.00'	102°51'	+1.00'	103°51'	+1.00'	104°51'	+1.00'	105°51'	+1.00'	106°51'	+1.00'	107°51'	+1.00'	108°51'	+1.00'	109°51'	+1.00'
2-	105°03'	+1.00'	106°05'	+0.99'	107°02'	+0.99'	108°02'	+0.99'	109°01'	+0.99'	110°01'	+0.99'	111°00'	+0.99'	111°59'	+0.98'	112°58'	+0.98'
3-	111°55'	+0.95'	112°52'	+0.95'	113°48'	+0.94'	114°45'	+0.94'	115°41'	+0.94'	116°38'	+0.93'	117°34'	+0.93'	110°30'	+0.93'	119°25'	+0.93
4-	123°53'	+0.80'	124°41'	+0.79'	125°29'	+0.79'	126°16'	+0.78'	127°03'	+0.78'	127°50'	+0.78'	128°37'	+0.78'	129°14'	+0.77'	130°10'	+0.77
5-	140°30'	+0.50'	141°00'	+0.50'	141°30'	+0.50'	142°00'	+0.50'	142°30'	+0.50'	143°00'	+0.50'	143°30'	+0.50'	144°00'	+0.50'	144°30'	+0.05'
6-	157°07'	+0.20'	157°19'	+0.21'	157°31'	+0.21'	157°44'	+0.22'	157°57'	+0.22'	158°10'	+0.22'	158°23'	+0.22'	158°36'	+0.22'	158°50'	+0.23'
7-	169°05'	+0.05'	169°08'	+0.05'	169°12'	+0.06'	169°15'	+0.06'	169°19'	+0.06'	169°22'	+0.07'	169°26'	+0.07'	169°30'	+0.07'	169°35'	+0.07'
8-	175°57'	+0.00'	175°57'	+0.01'	175°58'	+0.01'	175°58'	+0.01'	175°59'	+0.01'	175°59'	+0.01'	176°00'	+0.01'	176°00'	+0.02'	176°02'	+0.02'
9-	179°09'	-0.00'	179°09'	-0.00'	179°09'	-0.00'	179°09'	-0.00'	179°09'	+0.00'	179°09'	+0.00'	179°09'	+0.00'	179°09	+0.00'	179°09'	+0.00'
10-	180°00'	0.00'	180°00'	0.00'	100°00'	0.00'	180°00'	0.00'	180°00'	0.00'	180°00'	0.00'	180°00'	0.00'	180°00'	0.00'	180°00'	0.00'

Pts.	Δ = 110°	Diff. 1'	Δ = 111°	Diff. 1'	Δ = 112°	Diff. 1'	Δ = 113°	Diff. 1'	Δ = 114°	Diff. 1'	Δ = 115°	Diff. 1'	Δ = 116°	Diff. 1'	Δ = 117°	Diff. 1'	Δ = 118°	Diff. 1'
1-	110°51'	+1.00'	111°51'	+1.00'	112°51'	+1.00'	113°51'	+1.00'	114°51'	+1.00'	115°50'	+1.00'	116°50'	+1.00'	117°50'	+1.00'	118°50'	+1.00'
2-	113°57'	+0.98'	114°56'	+0.98'	115°55'	+0.98'	116°54'	+0.98'	117°53'	+0.98'	118°51'	+0.98'	119°50'	+0.98'	120°49'	+0.98'	121°47'	+0.97'
3-	120°21'	+0.92'	121°16'	+0.92'	122°12'	+0.92'	123°07'	+0.92'	124°02'	+0.91'	124°57'	+0.91'	125°51'	+0.91'	126°46'	+0.91'	127°40'	+0.90'
4-	130°57'	+0.76'	131°42'	+0.77'	132°28'	+0.76'	133°14'	+0.76'	134°00'	+0.76'	134°46'	+0.75'	135°30'	+0.75'	136°16'	+0.75'	137°01'	+0.75'
5-	145°00'	+0.50'	145°30'	+0.50'	146°00'	+0.50'	146°30'	+0.50'	147°00'	+0.50'	147°30'	+0.50'	148°00'	+0.50'	148°30'	+0.50'	149°00'	+0.50'
6-	159°03'	+0.24'	159°18'	+0.23'	159°32'	+0.24'	159°46'	+0.24'	160°00'	+0.24'	160°15'	+0.25'	160°30'	+0.25'	160°44'	+0.25'	160°59'	+0.25'
7-	169°39'	+0.08'	169°44'	+0.08'	169°48'	+0.08'	169°53'	+0.08'	169°58'	+0.09'	170°03'	+0.09'	170°09'	+0.09'	170°14'	+0.09'	170°20'	+0.10'
8-	176°03'	+0.02'	176°04'	+0.02'	176°05'	+0.02'	176°06'	+0.02'	176°07'	+0.02'	176°09'	+0.02'	176°10'	+0.02'	176°11'	+0.02'	176°13'	+0.03'
9-	179°09'	+0.00'	179°09'	+0.00'	179°09'	+0.00'	179°09'	+0.00'	179°09'	+0.00'	179°10'	+0.00'	179°10'	+0.00'	179°10'	+0.00'	179°10'	+0.00'
10-	180°00'	0.00'	180°00'	0.00'	180°00'	0.00'	100°00'	0.00'	180°00'	0.00'	180°00'	0.00'	180°00'	0.00'	180°00'	0.00'	180°00'	0.00'

Pts.	Δ = 119°	Diff. 1'	Δ = 120°	Diff. 1'	Δ = 121°	Diff. 1'	Δ = 122°	Diff. 1'	Δ = 123°	Diff. 1'	Δ = 124°	Diff. 1'	Δ = 125°	Diff. 1'	Δ = 126°	Diff. 1'	Δ = 127°	Diff. 1'
1-	119°50'	+1.00'	120°49'	+1.00'	121°49'	+1.00'	122°49'	+1.00'	123°48'	+1.00'	124°48'	+1.00'	125°48'	+1.00'	126°48'	+1.00'	127°47'	+1.00'
2-	122°46'	+0.97'	123°44'	+0.97'	124°42'	+0.97'	125°40'	+0.97'	126°39'	+0.97'	127°37'	+0.97'	128°35'	+0.96'	129°33'	+0.96'	130°30'	+0.96'
3-	128°34'	+0.90'	129°28'	+0.90'	130°23'	+0.90'	131°16'	+0.90'	132°10'	+0.89'	133°04'	+0.89'	133°57'	+0.89'	134°50'	+0.89'	135°43'	+0.88'
4-	137°45'	+0.74'	138°30'	+0.74'	139°15'	+0.74'	139°59'	+0.74'	140°43'	+0.72'	141°27'	+0.73'	142°11'	+0.73'	142°55'	+0.73'	143°39'	+0.73'
5-	149°30'	+0.50'	150°00'	+0.50'	150°30'	+0.50'	151°00'	+0.50'	151°30'	+0.50'	152°00'	+0.50'	152°30'	+0.50'	153°00'	+0.50'	153°30'	+0.50'
6-	161°15'	+0.26'	161°30'	+0.26'	161°45'	+0.26'	162°01'	+0.26'	162°17'	+0.27'	162°33'	+0.27'	162°49'	+0.27'	163°05'	+0.27'	163°21'	+0.27'
7-	170°26'	+0.10'	170°32'	+0.10'	170°37'	+0.10'	170°44'	+0.10'	170°50'	+0.11'	170°56'	+0.11'	171°03'	+0.11'	171°10'	+0.11'	171°17'	+0.12'
8-	176°14'	+0.03'	176°16'	+0.03'	176°18'	+0.03'	176°20'	+0.03'	176°21'	+0.03'	176°23'	+0.03'	176°25'	+0.04'	176°27'	+0.04'	176°30'	+0.04'
9-	179°10'	+0.00'	179°11'	+0.00'	179°11'	+0.00'	179°11'	+0.00'	179°12'	+0.00'	179°12'	+0.00'	179°12'	+0.00'	179°12'	+0.00'	179°13'	+0.00'
10-	180°00'	0.00'	180°00'	0.00'	180°00'	0.00'	180°00'	0.00'	180°00'	0.00'	180°00'	0.00'	180°00'	0.00'	180°00'	0.00'	180°00'	0.00'

Table I— Externals, Tangents, Radii and Degrees of Curve to a 100 ft. Circular Arc.

Δ	E	Diff. 10'	T	Diff. 10'	R	D	Deflec. per ft.
1°	0.218	.036	50.001	.001	5730	1°	0.3'
2°	0.436	.036	50.005	.001	2865	2°	0.6'
3°	0.655	.036	50.012	.001	1910	3°	0.9'
4°	0.873	.036	50.020	.002	1432	4°	1.2'
5°	1.092	.036	50.032	.002	1146	5°	1.5'
6°	1.310	.036	50.046	.003	955.0	6°	1.8'
7°	1.530	.036	50.062	.003	818.5	7°	2.1'
8°	1.749	.036	50.081	.004	716.2	8°	2.4'
9°	1.969	.036	50.103	.004	636.6	9°	2.7'
10°	2.189	.036	50.127	.005	573.0	10°	3.0'
11°	2.408	.037	50.155	.005	520.9	11°	3.3'
12°	2.630	.037	50.184	.005	477.5	12°	3.6'
13°	2.851	.037	50.216	.006	440.8	13°	3.9'
14°	3.072	.037	50.251	.006	409.3	14°	4.2'
15°	3.296	.037	50.288	.007	382.0	15°	4.5'
16°	3.519	.037	50.328	.007	358.1	16°	4.8'
17°	3.743	.037	50.370	.008	337.0	17°	5.1'
18°	3.968	.037	50.416	.008	318.3	18°	5.4'
19°	4.193	.038	50.463	.009	301.6	19°	5.7'
20°	4.419	.038	50.514	.009	286.5	20°	6.0'
21°	4.646	.038	50.567	.010	272.9	21°	6.3'
22°	4.875	.038	50.624	.010	260.4	22°	6.6'
23°	5.104	.038	50.682	.010	249.1	23°	6.9'
24°	5.334	.039	50.744	.011	238.8	24°	7.2'
25°	5.565	.039	50.809	.011	229.2	25°	7.5'
26°	5.797	.039	50.876	.012	220.4	26°	7.8'
27°	6.030	.039	50.946	.012	212.2	27°	8.1'
28°	6.264	.039	51.020	.013	204.6	28°	8.4'
29°	6.500	.040	51.096	.013	197.6	29°	8.7'
30°	6.737	.040	51.175	.014	191.0	30°	9.0'
31°	6.976	.040	51.257	.014	184.8	31°	9.3'
32°	7.216	.040	51.342	.015	179.1	32°	9.6'
33°	7.457	.040	51.430	.015	173.6	33°	9.9'
34°	7.700	.041	51.521	.016	168.5	34°	10.2'
35°	7.944	.041	51.615	.016	163.7	35°	10.5'
36°	8.190	.041	51.712	.017	159.2	36°	10.8'
37°	8.438	.042	51.813	.017	154.9	37°	11.1'
38°	8.688	.042	51.917	.018	150.8	38°	11.4'
39°	8.939	.042	52.024	.019	146.9	39°	11.7'
40°	9.193	.043	52.135	.019	143.2	40°	12.0'
41°	9.448	.043	52.249	.020	139.8	41°	12.3'
42°	9.706	.043	52.366	.020	136.4	42°	12.6'
43°	9.965	.044	52.487	.021	133.3	43°	12.9'
44°	10.227	.044	52.611	.021	130.2	44°	13.2'
45°	10.491	.044	52.739	.022	127.3	45°	13.5'
46°	10.757	.045	52.871	.022	124.6	46°	13.8'
47°	11.025	.045	53.006	.023	121.9	47°	14.1'
48°	11.296	.046	53.145	.024	119.4	48°	14.4'
49°	11.570	.046	53.288	.025	117.0	49°	14.7'
50°	11.846	.047	53.435	.025	114.6	50°	15.0'
51°	12.125	.047	53.585	.026	112.3	51°	15.3'
52°	12.407	.047	53.740	.027	110.2	52°	15.6'
53°	12.691	.048	53.899	.027	108.1	53°	15.9'
54°	12.979	.049	54.062	.028	106.1	54°	16.2'
55°	13.270	.050	54.230	.029	104.1	55°	16.5'
56°	13.564	.050	54.402	.029	102.1	56°	16.8'
57°	13.861	.050	54.577	.030	100.5	57°	17.1'
58°	14.161	.051	54.758	.031	98.79	58°	17.4'
59°	14.465	.051	54.943	.032	97.11	59°	17.7'
60°	14.773	.052	55.133	.032	95.49	60°	18.0'
61°	15.084	.053	55.328	.033	93.93	61°	18.3'
62°	15.399	.053	55.527	.034	92.41	62°	18.6'
63°	15.718	.054	55.732	.035	90.95	63°	18.9'
64°	16.041	.055	55.941	.036	89.52	64°	19.2'
65°	16.368	.055	56.156	.037	88.15	65°	19.5'
66°	16.699	.056	56.376	.038	86.82	66°	19.8'
67°	17.035	.057	56.602	.039	85.52	67°	20.1'
68°	17.374	.058	56.833	.040	84.27	68°	20.4'
69°	17.721	.058	57.070	.041	83.05	69°	20.7'
70°	18.071	.059	57.313	.042	81.86	70°	21.0'
71°	18.426	.060	57.562	.043	80.71	71°	21.3'
72°	18.785	.061	57.816	.044	79.59	72°	21.6'
73°	19.151	.062	58.078	.045	78.50	73°	21.9'
74°	19.522	.062	58.346	.046	77.44	74°	22.2'
75°	19.899	.064	58.619	.047	76.41	75°	22.5'
76°	20.281	.065	58.900	.048	75.40	76°	22.8'
77°	20.670	.066	59.188	.049	74.42	77°	23.1'
78°	21.064	.067	59.483	.051	73.47	78°	23.4'
79°	21.466	.068	59.787	.052	72.54	79°	23.7'
80°	21.873	.069	60.096	.053	71.62	80°	24.0'
81°	22.288	.070	60.414	.054	70.75	81°	24.3'
82°	22.710	.072	60.740	.056	69.89	82°	24.6'
83°	23.159	.073	61.074	.057	69.04	83°	24.9'
84°	23.575	.074	61.416	.059	68.22	84	25.2'
85°	24.020	.075	61.767	.060	67.43	85°	25.5'
86°	24.472	.077	62.127	.062	66.64	86°	25.8'
87°	24.934	.078	62.496	.063	65.87	87°	26.1'
88°	25.403	.080	62.875	.065	65.12	88°	26.4'
89°	25.882	.081	63.264	.066	64.39	89°	26.7'
90°	26.370	.083	63.662	.068	63.66	90°	27.0'
91°	26.867	.085	64.071	.070	62.96	91°	27.3'
92°	27.375	.086	64.491	.072	62.28	92°	27.6'
93°	27.893	.088	64.922	.074	61.61	93°	27.9'
94°	28.421	.090	65.364	.076	60.95	94°	28.2'
95°	28.960	.092	65.818	.078	60.31	95°	28.5'
96°	29.511	.094	66.285	.080	59.68	96°	28.8'
97°	30.074	.096	66.764	.082	59.07	97°	29.1'
98°	30.650	.098	67.256	.084	58.47	98°	29.4'
99°	31.238	.101	67.762	.087	57.87	99°	29.7'
100°	31.841	.103	68.282	.089	57.30	100°	30.0'
101°	32.456	.105	68.817	.092	56.73	101°	30.3'
102°	33.086	.108	69.367	.094	56.17	102°	30.6'
103°	33.731	.110	69.933	.097	55.63	103°	30.9'
104°	34.392	.113	70.515	.100	55.09	104°	31.2'
105°	35.069	.116	71.114	.104	54.57	105°	31.5'
106°	35.763	.119	71.730	.106	54.05	106°	31.8'
107°	36.475	.122	72.365	.109	53.55	107°	32.1'
108°	37.205	.125	73.019	.113	53.05	108°	32.4'
109°	37.955	.128	73.694	.116	52.56	109°	32.7'
110°	38.724	.132	74.388	.119	52.09	110°	33.0'
111°	39.514	.136	75.104	.123	51.62	111°	33.3'
112°	40.327	.139	75.863	.127	51.16	112°	33.6'
113°	41.162	.143	76.606	.131	50.70	113°	33.9'
114°	42.021	.147	77.393	.134	50.26	114°	34.2'
115°	42.905	.152	78.205	.140	49.82	115°	34.5'
116°	43.816	.157	79.045	.145	49.39	116°	34.8'
117°	44.755	.161	79.913	.150	48.97	117°	35.1'
118°	45.721	.166	80.811	.155	48.56	118°	35.4'
119°	46.718	.172	81.739	.160	48.15	119°	35.7'
120°	47.747	.177	82.699	.166	47.75	120°	36.0'
121°	48.809	.183	83.694	.172	47.35	121°	36.3'
122°	49.907	.189	84.725	.178	46.96	122°	36.6'
123°	51.042	.196	85.793	.185	46.58	123°	36.9'
124°	52.216	.203	86.901	.192	46.21	124°	37.2'
125°	53.431	.210	88.051	.199	45.84	125°	37.5'
126°	54.690	.218	89.248	.207	45.47	126°	37.8'
127°	55.995	.226	90.486	.215	45.11	127°	38.1'
128°	57.348	.	91.776		44.76	128°	38.4'

Table II

Deg. Curve	Radius	MIDDLE ORDINATES for Chords of					CHORDS for Arcs of				
		100ft	80ft	60ft	50ft	40ft	100ft	80ft	60ft	50ft	40ft
1°	5730	0.2	0.1	0.1	0.0	0.0	100	80	60	50	40
2°	2865	0.4	0.3	0.2	0.1	0.1	100	80	60	50	40
3°	1910	0.6	0.4	0.2	0.2	0.1	100	80	60	50	40
4°	1432.5	0.9	0.6	0.3	0.2	0.1	100	80	60	50	40
5°	1146	1.1	0.7	0.4	0.3	0.2	100	80	60	50	40
6°	955.0	1.3	0.8	0.5	0.3	0.2	100	80	60	50	40
7°	818.5	1.5	1.0	0.5	0.4	0.3	99.94	80	60	50	40
8°	716.2	1.8	1.1	0.6	0.4	0.3	99.92	80	60	50	40
9°	636.6	2.0	1.2	0.7	0.5	0.3	99.90	79.95	60	50	40
10°	573.0	2.2	1.4	0.8	0.5	0.3	99.88	79.93	60	50	40
		for Chords of					for Arcs of				
		80ft	60ft	50ft	40ft	30ft	80ft	60ft	50ft	40ft	30ft
11°	520.9	1.5	0.9	0.6	0.4	0.2	79.92	60	50	40	30
12°	477.5	1.7	0.9	0.7	0.4	0.2	79.91	60	50	40	30
13°	440.8	1.8	1.0	0.7	0.4	0.2	79.89	60	50	40	30
14°	409.3	2.0	1.1	0.8	0.5	0.3	79.87	59.95	50	40	30
15°	382.0	2.1	1.2	0.8	0.5	0.3	79.85	59.94	50	40	30
16°	358.1	2.2	1.3	0.9	0.6	0.3	79.83	59.93	49.95	40	30
17°	337.0	2.4	1.3	0.9	0.6	0.3	79.81	59.92	49.95	40	30
		for Chords of					for Arcs of				
		60ft	50ft	40ft	30ft	25ft	60ft	50ft	40ft	30ft	25ft
18°	318.3	1.4	1.0	0.6	0.3	0.2	59.91	49.94	40	30	25
19°	301.6	1.5	1.0	0.7	0.4	0.3	59.90	49.94	40	30	25
20°	286.5	1.5	1.1	0.7	0.4	0.3	59.89	49.94	40	30	25
21°	272.9	1.7	1.1	0.7	0.4	0.3	59.88	49.93	40	30	25
22°	260.4	1.7	1.2	0.8	0.4	0.3	59.87	49.93	40	30	25
23°	249.1	1.8	1.3	0.8	0.5	0.3	59.84	49.91	40	30	25
24°	238.8	1.9	1.3	0.8	0.5	0.3	59.84	49.91	40	30	25
25°	229.2	2.0	1.4	0.9	0.5	0.3	59.82	49.90	39.95	30	25
26°	220.4	2.0	1.4	0.9	0.5	0.3	59.81	49.90	39.95	30	25
27°	212.2	2.1	1.5	0.9	0.5	0.4	59.79	49.89	39.94	30	25
28°	204.6	2.2	1.5	1.0	0.5	0.4	59.78	49.88	39.94	30	25
29°	197.6	2.3	1.6	1.0	0.6	0.4	59.77	49.87	39.93	30	25
30°	191.0	2.3	1.6	1.0	0.6	0.4	59.75	49.87	39.93	30	25
31°	184.8	2.4	1.7	1.1	0.6	0.4	59.74	49.86	39.92	30	25
32°	179.1	2.5	1.7	1.1	0.6	0.4	59.73	49.84	39.92	30	25
		for Chords of					for Arcs of				
		50ft	30ft	25ft	20ft	10ft	50ft	30ft	25ft	20ft	10ft
33°	173.6	1.8	0.6	0.4	0.3	0.1	49.83	30	25	20	10
34°	168.5	1.8	0.7	0.5	0.3	0.1	49.82	30	25	20	10
35°	163.7	1.9	0.7	0.5	0.3	0.1	49.81	30	25	20	10
36°	159.2	2.0	0.7	0.5	0.3	0.1	49.80	30	25	20	10
37°	154.9	2.0	0.7	0.5	0.3	0.1	49.79	29.95	25	20	10
38°	150.8	2.1	0.7	0.5	0.3	0.1	49.78	29.95	25	20	10
39°	146.9	2.1	0.8	0.5	0.3	0.1	49.77	29.95	25	20	10
40°	143.2	2.2	0.8	0.5	0.3	0.1	49.76	29.94	25	20	10
41°	139.8	2.2	0.8	0.6	0.4	0.1	49.74	29.94	25	20	10
42°	136.4	2.3	0.8	0.6	0.4	0.1	49.73	29.94	25	20	10
43°	133.3	2.3	0.8	0.6	0.4	0.1	49.71	29.93	25	20	10
44°	130.2	2.4	0.9	0.6	0.4	0.1	49.69	29.93	25	20	10
45°	127.3	2.4	0.9	0.6	0.4	0.1	49.67	29.92	25	20	10
46°	124.6	2.5	0.9	0.6	0.4	0.1	49.66	29.92	25	20	10
47°	121.9	2.6	0.9	0.6	0.4	0.1	49.63	29.92	24.96	20	10
48°	119.4	2.6	0.9	0.6	0.4	0.1	49.62	29.92	24.95	20	10
49°	117.0	2.7	1.0	0.7	0.4	0.1	49.60	29.91	24.95	20	10
50°	114.6	2.7	1.0	0.7	0.4	0.1	49.59	29.91	24.94	20	10

Table III

Deg. Curve	Radius	MIDDLE ORDINATES for Chords of					CHORDS for Arcs of				
		50ft	30ft	25ft	20ft	10ft	50ft	30ft	25ft	20ft	10ft
51°	112.4	2.8	1.0	0.7	0.4	0.1	49.57	29.91	24.94	20	10
52°	110.2	2.8	1.0	0.7	0.4	0.1	49.56	29.90	24.94	20	10
53°	108.1	2.9	1.0	0.7	0.5	0.1	49.55	29.90	24.94	20	10
54°	106.1	2.9	1.1	0.7	0.5	0.1	49.54	29.90	24.94	20	10
55°	104.2	3.0	1.1	0.7	0.5	0.1	49.53	29.89	24.93	20	10
56°	102.3	3.0	1.1	0.8	0.5	0.1	49.51	29.89	24.93	20	10
57°	100.5	3.1	1.1	0.8	0.5	0.1	49.49	29.89	24.93	20	10
58°	98.8	3.1	1.1	0.8	0.5	0.1	49.47	29.88	24.92	20	10
59°	97.1	3.2	1.1	0.8	0.5	0.1	49.45	29.88	24.92	20	10
60°	95.5	3.2	1.2	0.8	0.5	0.1	49.43	29.88	24.92	20	10
		for Chords of					for Arcs of				
		50ft	25ft	20ft	15ft	10ft	50ft	25ft	20ft	15ft	10ft
61°	93.9	3.3	0.8	0.5	0.3	0.1	49.41	24.92	20	15	10
62°	92.6	3.4	0.8	0.5	0.3	0.1	49.39	24.92	20	15	10
63°	90.9	3.4	0.8	0.6	0.3	0.1	49.37	24.91	20	15	10
64°	89.5	3.5	0.9	0.6	0.3	0.1	49.35	24.91	20	15	10
65°	88.2	3.5	0.9	0.6	0.3	0.1	49.33	24.91	20	15	10
66°	86.8	3.6	0.9	0.6	0.3	0.1	49.31	24.91	20	15	10
67°	85.5	3.6	0.9	0.6	0.3	0.1	49.29	24.91	19.95	15	10
68°	84.2	3.7	0.9	0.6	0.3	0.1	49.27	24.90	19.95	15	10
69°	83.0	3.8	0.9	0.6	0.3	0.2	49.25	24.90	19.95	15	10
70°	81.8	3.8	1.0	0.6	0.3	0.2	49.23	24.90	19.95	15	10
71°	80.7	3.9	1.0	0.6	0.3	0.2	49.21	24.90	19.94	15	10
72°	79.6	3.9	1.0	0.6	0.4	0.2	49.19	24.89	19.94	15	10
73°	78.5	4.0	1.0	0.6	0.4	0.2	49.16	24.89	19.94	15	10
74°	77.4	4.0	1.0	0.6	0.4	0.2	49.13	24.89	19.94	15	10
75°	76.2	4.1	1.0	0.7	0.4	0.2	49.11	24.88	19.94	15	10
76°	75.4	4.2	1.0	0.7	0.4	0.2	49.09	24.88	19.94	15	10
77°	74.4	4.2	1.0	0.7	0.4	0.2	49.06	24.88	19.93	15	10
78°	73.4	4.2	1.1	0.7	0.4	0.2	49.04	24.87	19.93	15	10
79°	72.5	4.3	1.1	0.7	0.4	0.2	49.01	24.87	19.93	15	10
80°	71.6	4.4	1.1	0.7	0.4	0.2	48.99	24.87	19.93	15	10
81°	70.8	4.4	1.1	0.7	0.4	0.2	48.96	24.87	19.93	15	10
82°	69.9	4.5	1.1	0.7	0.4	0.2	48.94	24.86	19.92	15	10
83°	69.1	4.5	1.1	0.7	0.4	0.2	48.91	24.86	19.92	15	10
84°	68.2	4.6	1.1	0.7	0.4	0.2	48.89	24.86	19.92	15	10
85°	67.4	4.6	1.2	0.7	0.4	0.2	48.86	24.86	19.92	15	10
86°	66.6	4.7	1.2	0.8	0.4	0.2	48.83	24.85	19.92	15	10
87°	65.9	4.8	1.2	0.8	0.4	0.2	48.81	24.85	19.92	15	10
88°	65.1	4.8	1.2	0.8	0.4	0.2	48.78	24.84	19.92	15	10
89°	64.4	4.9	1.2	0.8	0.4	0.2	48.76	24.84	19.91	15	10
90°	63.7	4.9	1.2	0.8	0.4	0.2	48.73	24.84	19.91	15	10
91°	63.0	5.0	1.2	0.8	0.4	0.2	48.70	24.83	19.91	15	10
92°	62.3	5.0	1.2	0.8	0.4	0.2	48.67	24.83	19.91	15	10
93°	61.6	5.1	1.3	0.8	0.5	0.2	48.64	24.82	19.91	15	10
94°	60.9	5.1	1.3	0.8	0.5	0.2	48.61	24.82	19.90	15	10
95°	60.3	5.2	1.3	0.8	0.5	0.2	48.58	24.82	19.90	15	10
96°	59.7	5.2	1.3	0.8	0.5	0.2	48.55	24.81	19.90	15	10
97°	59.1	5.3	1.3	0.8	0.5	0.2	48.52	24.81	19.90	15	10
98°	58.5	5.3	1.3	0.8	0.5	0.1	48.49	24.81	19.90	15	10
99°	57.9	5.4	1.3	0.9	0.5	0.2	48.46	24.80	19.90	15	10
100°	57.3	5.4	1.4	0.9	0.5	0.2	48.43	24.80	19.90	15	10

ber of the P.C., is known, hence its location can be checked by measuring the plus distance back to the preceding station. This method avoids measuring the tangent distance from the P.I., in order to locate the P.C.

It should be noted that the curve can be located by starting at the P.C., instead of the P.T., the deflection to the first point being the same as that to the 9th point as given by Table I. If part of the curve is not visible from the P.I., say that beyond 6, then the instrument may be moved to point 6 and the remaining points located by deflections from a preceding chord. Suppose a backsight is taken to point 2, vernier reading 0°, then after reversing the telescope the proper deflection to locate point 7 is $\frac{5\triangle^\circ}{2\text{x}10} = \frac{\triangle^\circ}{4}$, etc.

For very long curves in woods and at places where the P.I., is not accessible, the well known deflection method should be used, that is, the instrument is moved to the P.C., and intermediate points on the curve.

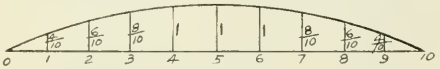

Fig. 3.

During the past summer the writer was in charge of a party that surveyed 22 miles of federal-aid highways in hilly and mountainous country, and the following facts were observed: (1) not a single case of inaccessible P.I. occurred, (2) along 86 per cent of the curves, the P.I. was visible throughout, (3) in only 42 per cent of the curves was the P.T. visible from the P.C. This means that 86 per cent of the curves could have been laid out completely with the instrument set only once (at the P.I.), whereas 58 per cent of them actually required the instrument to be set up three times. The first 11 miles was in fairly open country along the general direction of an old road. Here 96 per cent of the curves were visible throughout from the P.I., but 70 per cent of the P.T. points were not visible from the P.C. The other 11 miles of the survey was partly in a dense forest and not along an old road.

Aside from the time saved in not having to move the instrument, another step in the usual operation of laying out a curve is avoided, and that is, the tangent distance is not measured from the P.I., in order to locate the P.C. Curves laid out by the usual method begin and end with subchords of unequal length This makes the deflections rather tedious to compute. The errors are cumulative, and the writer has seen the best of transitmen waste time in trying to find the little error that prevented the final check.

The resident engineer can more easily pick up the P.I. than any other point and he would find it convenient to realign the curve by deflections from this position while construction is going on, since it is apt to be beyond the grade stakes and not disturbed.

The points on the curve established by deflections according to the proposed new method are at equal and integral distances apart, but they are not full stations. The writer believes the advantages of full station points are largely imaginative. However, the chainmen can easily locate full station points on their return trip from the P.C. to the P.T., as is explained in Example 1. The middle ordinate of the equal chords can be found in Table III which has been compiled by the writer for the purpose. In this connection, it should be remembered that middle ordinates vary practically as the square of the chords; and for any chord, the ordinates vary practically as those of a parabola. See Fig. 3. Thus if the middle ordinate is 1 ft., the ordinate (or offset) at a point 2/5th of the chord-length from the end of the chord is 0.6 ft. The middle ordinate in practice is usually less than 1 ft. as will be seen later.

Before proceeding with an illustration, Table II will be explained. This table gives the externals, tangents, radii and degrees of curve for circular arcs of 100 ft. in length according to values of the deflection angle ranging from 1° to 128°. It is offered as a substitute for the tables giving the functions of a 1° curve. The following formulas were used in computing the values in Table II:

$$D = \frac{100}{L} = \frac{100\triangle}{100} = \triangle,$$

$$R = \frac{5729.578}{D},$$

$$T = R \tan \tfrac{1}{2} \triangle = \frac{5729.578}{\triangle} \tan \tfrac{1}{2} \triangle,$$

$$E = R \tan \tfrac{1}{2} \triangle = \frac{5729.578}{\triangle} \operatorname{exsec} \tfrac{1}{2} \triangle.$$

For curves longer than 100 ft., the tabular values of the external, tangent, and radius must be multiplied, and the degree of curve divided, by the ratio of the given curve length to 100. For example, suppose △ is 24° and the length of curve to be used is 400 ft., then E = 5.334 × 4 = 21.3, T = 50.744 × 4 = 203.0, D = 24/4 = 6°, R = 238.8 × 4 = 955.2. This table gives conveniently a length of curve that will always be a multiple of ten. The chord-lengths therefore will always be an integral number of feet in length.

Example 1.

Given △ = 40° 00′; P.I. at Sta. 62 + 11.8.

From Table II, L = 100, E = 9.193, T = 52.135, D = 40°.

Suppose local conditions are such that E should equal 46 ft. approximately. Hence, ratio = 46/9.2 = 5 .

L = 500, E = 46.0, T = 260.7, D = 8°.

500/10 = 50 = length of each chord to be applied 10 times.

$$\begin{array}{rl} \text{P.I.} & = 62 + 11.8 \\ \text{T} & = 2 + 60.7 \\ \hline \text{P.C.} & = 59 + 51.1 \\ \text{L} & = 5 \\ \hline \text{P.T.} & = 64 + 51.1 \end{array}$$

For △ = 40° 00′, the deflections are given directly in Table I as follows:

Points.		Deflections. Δ°
Sta. 64 + 51.1 — P.T.		
Sta. 64 + 01.1 — 1st		40° 29′
Sta. 63 + 51.1 — 2nd		42° 29′
Sta. 63 + 01.1 — 3rd		47° 58′
Sta. 62 + 51.1 — 4th		63° 41′
Sta. 62 + 01.1 — 5th	(E = 46.0)	110° 00′
Sta. 61 + 51.1 — 6th		156° 19′
Sta. 61 + 01.1 — 7th		172° 02′
Sta. 60 + 51.1 — 8th		177° 31′
Sta. 60 + 01.1 — 9th		179° 31′
Sta. 59 + 51.1 — 10th P.C.		180° 00′

As a check in taking deflections from the table, it should be noted that the 1st + 9th = 2nd + 8th = 3rd + 7th = 4th + 6th = 180 + △ = 220° 00′.

The above points on the curve are not at full stations; but the chainmen, on their way back from the P.C., can very easily set stakes at full station and + 50-ft. points as follows: the rear chainman holds the + 51.1 division of the tape at the P.C., and aligns the front chainman by sighting to the 9th point of the curve; then a right angle offset on the P.I. side of the curve, at a certain fraction (see Fig. 3) of the middle ordinate for a chord of 50 ft. (see Table III), locates Sta. 60 (in this case the middle ordinate is 0.44 ft. and the offset is less than 0.1 ft.); next the rear chairman holds the zero end of the tape at Sta. 60 and aligns the front chainman by sighting from the 9th point to the 8th point, in order to locate Sta. 60 + 50 which is so near the 8th point it does not have to be shifted. The other stations are established in a similar manner.

Example 2.

Given △ = 20° 20′; P.I. at Sta. 37 + 18.2.

T = 50.532, E = 4.5 (Table II).

Suppose T = 100 = approx. desired length of tangent.

Ratio = 2, hence L = 200, T = 101.0, D = 10° 10′.

$$\begin{array}{rl} \text{P.I.} & = 37 + 18.2 \\ \text{T} & = 1 + 01.0 \\ \hline \text{P.C.} & = 36 + 17.2 \\ \text{L} & = 2 \\ \hline \text{P.T.} & = 38 + 17.2 \end{array}$$

200/10 = 20. Use 40 ft. chords applied five times.

Points.	Deflections. Δ°
P.T.	
2nd	21° 40′
4th	35° 13′
6th	165° 07′
8th	178° 40′
10th P.C.	180° 00′

2nd + 8th = 4th + 6th = 200° 20′. Check.

The quantities in Tables II and III are based on the definition that the "degree of curve" is the central angle subtended by an arc of 100 ft. instead of a chord of 100 ft. The radius of a 1° curve is found by means of the following proportion:

1° : 360° = 100 ft. : 2 π R feet,

$$\text{hence } R = \frac{36000}{2\pi} = \frac{36000}{2(3.14159)} = 5729.578 \text{ ft.}$$

The middle ordinate (M) of an arc whose central angle is $\alpha°$ and whose chord is c feet, is given by the formula:

$M = R \text{ vers } \frac{1}{2}\alpha$ ....(4)

Also $M = c^2/8R$ approx. ....(5)

Formula (5) shows that for any radius, the middle ordinates vary as the square of the chords. The above formulas were used in computing Table III.

Assuming the arc to be parabolic, we have a convenient relation between ordinates at any point along the chord and the middle ordinate. See Fig. 3. For example, an ordinate at 8/10 of the chord-length from one end of the chord is 6/10 of the middle ordinate.

In practice, the middle ordinate is usually less than 1.0 ft., provided the chords do not exceed the limit where they vary more than 0.05 ft. from the arc. Table III shows these limits to be as follows:

100 ft. chords up to 6° curves; middle ordinates up to 1.31 ft.
50 ft. chords up to 16° curves; middle ordinates up to 0.87 ft.
40 ft. chords up to 25° curves; middle ordinates up to 0.87 ft.
30 ft. chords up to 37 curves; middle ordinates up to 0.72 ft.
25 ft. chords up to 47 curves; middle ordinates up to 0.64 ft.
20 ft. chords up to 67 curves; middle ordinates up to 0.58 ft.
15 ft. chords up to 100 curves, middle ordinates up to 0.49 ft.

Cost of Hauling Gravel With Motor Truck

In a paper presented recently at a meeting of the Provincial District Engineers of British Columbia, Mr. G. B. Whitehead, District Engineer, gave the following particulars of his experiences in hauling gravel with motor trucks.

The truck operated in District No. 3 this past season was a 3½-ton Diamond T equipped with 4-yd. gravel box. This truck was worked in conjunction with hired trucks. As the truck arrived late in the season and the driver was only getting used to it at the end of the work and the road traveled over was not in the best shape, the costs will probably be bettered next season.

The trucks were loaded from bunkers and eight hours constituted a day's work. The initial haul was 2.3 miles on which 10 trips a day were kept up until 2.9 miles were reached, making an average return trip of 5.2 miles a day. From 3.4 to 3.7 miles, eight trips were obtained, the average return trip being 7.1 miles or 56.8 miles a day. From 3.7 to 4.6 miles, seven trips were obtained with an average return trip of 8.3 miles or 58.1 miles a day.

The costs given below will be based on the work of the Diamond T truck for 15½ days on an average haul of 4.15 miles or 8.3 miles return trip.

Driver's wages, 15½ days at $6	$ 93.00
Gasoline, oil and grease	93.30
Minor repairs	20.00
	$206.30

Material hauled, 432 cu. yd., cost per yard hauling, 48 ct.

These figures do not go into interest charges, depreciation of truck, or renewal of tires; but are simply data gathered for the purpose of basing the contracting of gravel work next season.

This season we paid $26 a day for rented trucks, everything found. The rented trucks had only a capacity of 2½ yd. and on the average haul of 4.15 miles, the material delivered cost us $1.48 per cubic yard, as against 48 ct. with our own truck. The difference of $1 is too much as a charge for depreciation and profit and is due to two reasons, one of which can be rectified. First, the capacity of the trucks, second, the fact that the other truck owners felt that when they made the same number of trips as our slower and heavier loaded truck they were fulfilling their contract. This could have been overcome in the rental agreement by calling for the speed for which the particular truck is catalogued.

Care should be taken to balance the number of trucks used so as to insure economical loading. For example, at one time we found that we could not keep our bunkers supplied with one slip team, but that by employing two teams they both stood idle about a third of the day. By putting on two extra trucks both teams could be kept busy and the extra trucks worked, without extra loading cost.

The difference in time between mechanical dumps and hand dumps averaged about 3 minutes. On short hauls this would become a factor that would have to be considered.

Flowability of Concrete and Its Measurement by Means of the "Flow-Table"*

By G. M. WILLIAMS,
Associate Engineer, U. S. Bureau of Standards.

The term flowability is one of the several expressions sometimes used to describe the consistency of placeability of concrete. The quality of a concrete or mortar mixture which has to do with ease of placing may be referred to as "consistency," "mobility," "plasticity," "workability," or "flowability," and these words, although having perhaps slightly different meanings to many people, are generally synonymous as used.

The consistency or flowability which must be used in any case is dependent upon the nature of the work, type and arrangement of forms and reinforcing steel. For any given condition there is some minimum flowability which must be attained to result in good workmanship and in economy and proper progress in the process of concreting. With given materials and proportions, flowability may be increased only by the use of more mixing water which will in turn lower compressive strength. It is generally agreed that concretes must have the same consistency or flowability to be comparable as to strength, yet we have had no satisfactory method for measuring and controlling consistency. Consistency has usually been crudely estimated by eye or the judgment or feel of the operator, and as a result, test data obtained even in the same laboratory, must in many cases remain as small and isolated groups of tests, none of which bears any definite and known relation to the others. Studies made of the results of such tests are likely to lead to faulty conclusions since such concretes are not comparable.

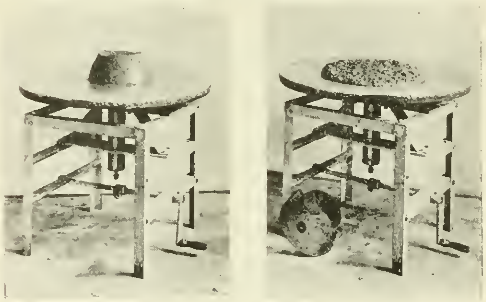

Fig. 1—Flow-table for Measuring the Consistency of Concrete as Used in the Concrete Laboratory of the Bureau of Standards.

A mass of concrete is molded in the shape of a frustum of a cone. The form is removed and by means of a cam the table top is raised ½ in. and dropped 15 times. The flowability is determined by measuring the spread of the mass by means of a self-reading proportional caliper, or can be calculated by dividing the new diameter by the old and multiplying by 100. The concrete shown is a 1:1½:3 proportion with a flowability of 170 at 5 minutes after mixing. This is about the stiffest consistency which can be used in structural work.

The cylinder slump test and its modification, the cone slump, have been proposed and used for this purpose, and while they are far superior to the old method of "eye" and "feel," they fail to fully meet the requirements of such a test. One criticism of both is that the concrete seldom really slumps when the form is withdrawn, but the mass merely collapses into an unsympathetic pile. In this respect the cone slump is less satisfactory than the cylinder, since when the former is employed the mass loses all lateral support as soon as the upward movement of the form is started and the tendency of the top to fall over is unresisted. A further criticism of both slump tests is that with different gradations of aggregates, or with different proportions of cement to aggregate, equal slumps do not result in concretes of equal flowabilities, so that the resulting concretes are not comparable.

Investigations in the concrete laboratory of the Bureau of Standards have emphasized that the control and the measurement of flowability is of fundamental importance, not only in laboratory testing of concrete but in the practical application of the results of such investigations to concreting practice in the field.

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During the past year and a half a new form of consistency measuring apparatus, designated as the "Flow-table," has been used in the concrete laboratory of the bureau. The type first employed consisted of a piece of sheet steel about 30 in. square, supported at its center in a horizontal position. A mass of concrete was molded at the center, the mold withdrawn, and the edge of the plate struck a given number of weighted, downward blows with a suitable hammer arrangement. The amount of spread of the mass was a measure of the flowability of the concrete.

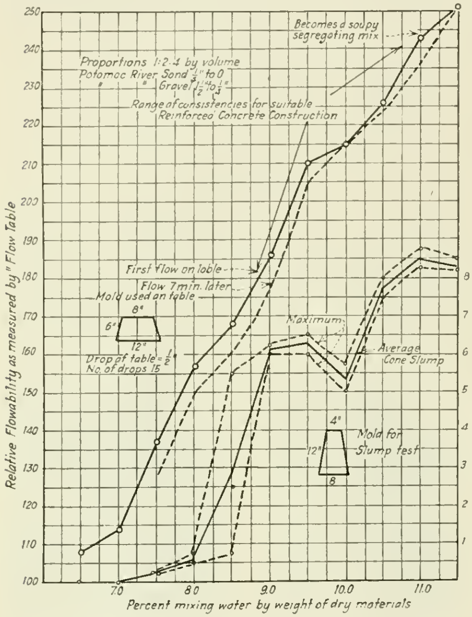

Fig. 2—Relation Between "Flowability" of Concrete as Measured by "Flow Table" and Quantity of Mixing Water for Five Separate Batches of 1:2½:3½ Concrete.

The preceding type of apparatus gave very satisfactory results, but further experiment resulted in a table of the type shown in Figure 1. This consists of a metal covered table top which can be raised vertically by means of a cam working the end of a vertical post to which the top is attached. The height of drop can be adjusted by means of a bolt at the lower end of the shaft. A mass of concrete or mortar is molded at the center of the table in a sheet metal mold which has the shape of a hollow frustrum of a cone. For aggregates up to 2 in. maximum size this cone has a height of 6 in. and upper and lower diameters of 8 in. and 12 in. For smaller aggregates when made up in small quantities, a cone having a height of 3 in. and upper and lower diameters of 4 in. and 6 in. is used. The mass of concrete is tamped just sufficiently to completely fill the form, the form is withdrawn, and the table top is dropped 15 times through a distance of ½ in. The mass flattens and usually spreads concentrically. Two diameters at right angles to each other are measured, the long and the short, if difference is apparent, by means of a self-reading caliper which is so graduated that the sum of the two readings is the value for "flowability," which may also be calculated by dividing the new diameter by the old and multiplying by 100.

A typical curve showing the relation between the flowability of concrete as measured by the "flow-table," and the quantity of mixing water used is shown in Fig. 2. Five separate batches of 1:2½:3½ volume proportion concrete were prepared with percentages of mixing water ranging from 7 to 11. Seven per cent resulted in a concrete too dry for ordinary construction work. Nine per cent of mixing water resulted in a concrete which flowed sluggishly in a steel chute which had an angle of 21 degrees. Ten per cent furnished as wet and fluid a concrete as is ever needed in practice. With 11 per cent a sloppy, segregating concrete difficult to properly sample was obtained. The added water in excess of 10 per cent resulted in practically no increase in flowability as measured by both the flow-table and the steel chute. This straight line relation between mixing water and flow as measured by the flow-table is characteristic of results obtained with other concretes, mortars, neat cement and lime pastes.

Figure 3 shows graphically some results of tests in which the "flow-table" and the "cone slump" were used. A single batch of concrete was employed in this case for all determinations shown, additional quantities of mixing water being added for each ½ per cent increase. Due to loss of paste, absorption, etc., a slightly flatter curve was obtained with the flow-table than resulted for the individual batches of concrete included in Fig. 2. With the exception of the dip in the curve for 10 per cent mixing water, the values for the cone slump are of the usual order of accuracy obtained by either of the slump methods. It is seen that the change in values for the "cone" between 8½ per cent and 9 per cent, omitting the 5½ in. slump for 8½ per cent, is greater than that caused by the addition of all the mixing water beyond 9 per cent. A really desirable and necessary consistency for reinforced concrete work was not obtained until 9 per cent mixing water was used. It is characteristic of consistency measurements made by the slump methods that marked differences in slump result for differences in quantity of mixing water over a very narrow range only, and usually before practical working consistencies are obtained.

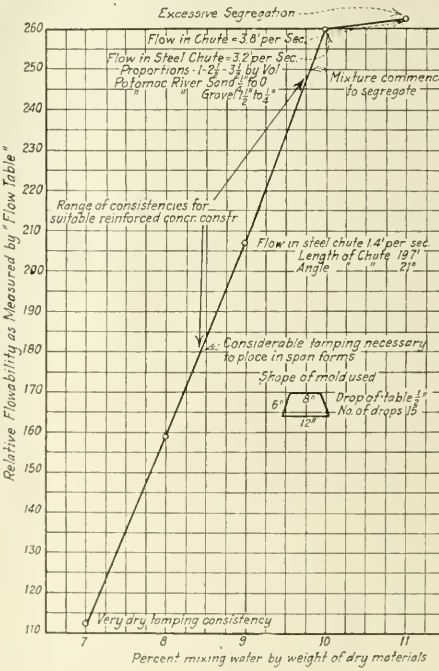

Fig. 3—Consistency of Concrete as Measured by the "Flow Table" and the "Cone Slump" Test. A Single Batch of Concrete Was Used in These Tests, Additions of ½ Per Cent Mixing Water Being Made After Each Group of Determinations.

The advantages of the "flow-table" over the slump methods may be listed as follows:

The flow-table accurately measures flowability or consistency of a concrete, mortar, cement or lime pastes for all consistencies varying from dry masses which have only a slight tendency to flow or change their shape when acted upon by external forces, to those consistencies which are so fluid that the water and laitance will flow away from the coarse aggregate.

The relation between flowability and quantity of mixing water is practically a straight line relation for all workable and usable mixtures and consistencies.

The stiffening of a mass of concrete due to absorption of water by the aggregate, evaporation or setting of the cement is indicated by reduction of flow of the mass on the flow table.

The rapid stiffening due to absorption of water by the cement and the aggregate is so marked that it is found necessary to measure the flowability at some definite interval of time after the addition of the mixing water. This is especially necessary when working with concretes composed of aggregates varying widely in gradation. This time interval is that which would be required in practice to properly place the concrete in the forms.

While the apparatus shown in Fig. 1 is rather heavy and cumbersome for use in the field, the method of test is fully applicable to field conditions, and a machine of more recent design now used in the laboratory can easily be carried about by one man. So far as comparative tests have been made on various tables, the results indicate that flow for any given number of bumps and height of drop is independent of the weight of the top, so that in standardizing the apparatus consideration need be given only to (a) size and shape of molded specimen, (b) height of drop of the table top, and (c) number of drops of the table top.

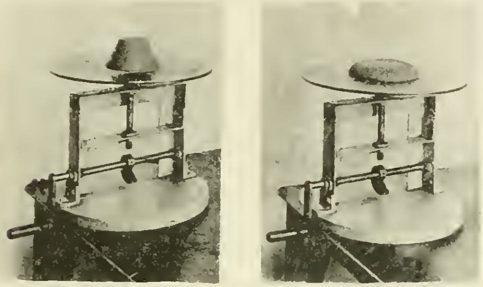

Fig. 4—Flow-table as Used in the Cement Testing Laboratory of the Bureau of Standards for Determining the Normal Consistency of Neat Cement and Standard Sand Mortars.

More consistent and accurate results are obtained by this apparatus than by the "ball" method or the Vicat needle. The 1:3 standards and mortar shown has a flowability of 126. The flowability for normal consistency of the same mixture is 110.

Although the flow-table was first employed as a means of measuring consistency of concrete, its use has indicated that it may be of value in the control and measurement of several other properties involved in the tests of cement and concrete.

Segregation.—In working with dry concretes or concrete having a small ratio of cement to aggregate, or small quantity of fine aggregate, it has been noted that considerable of the coarse aggregate may be found outside of the well defined line of mortar which is considered as the flow line. The quantity of such coarse material appears to be a measure of the harshness or tendency to segregate, and such observations will permit of determination in the laboratory of the ease of working in the field of different combinations of aggregates whose flowabilities are the same.

Time of Set.—The rate of hardening of mortar or concrete from the time mixing water is added is measured by "flow" of separate specimens on the table at intervals. A practical application was the determination of the rate of hardening of two mortar floor toppings, one containing an accelerator, on actual construction work. The mortar containing the accelerator was finished in one-half of the time required for the other, and the rate of hardening as measured on the flow-table was twice as fast for the former.

Normal Consistency.—The apparatus shown in Fig. 4 has been in use in the cement testing laboratory of the Bureau for checking determinations of the quantity of mixing water required for normal consistency of neat cement and standard sand mortars. Results so far obtained indicate the method to be more accurate and consistent than determinations by the "ball method" or the Vicat Needle.

Selection of Concretes for Field Use.—The flow table furnishes a means of measuring and expressing the missing factor "flowability" which is needed to permit of predicting in advance the approximate strength values which may be obtained for any given proportions of cement and aggregate. The ranges of strength values which may be expected for any aggregate when used with varying cement content and for the extreme ranges of consistencies needed in practice can be determined by a series of tests. Knowing in advance the type of construction, experience will permit the minimum usable flowabilities to be estimated, and for any required strength values the necessary ratios of cement to aggregate may be selected. The selections may be checked by the results of field tests of concrete, and a few trials will indicate strength variations which may result for the degree of thoroughness of field inspection employed, and permit of proper allowance for unavoidable variations in cements, aggregates, and curing conditions, etc.

The foregoing descriptions of the flow-table and its method of use is given with the hope that those who are interested in the testing of concrete will give the method a trial. No doubt further tests under widely different conditions will point out modifications and changes in the method and apparatus which will increase its value and any criticism based upon its application under such conditions will be appreciated.

Method of Patching Concrete Pavement

An excellent method of repairing cuts in concrete pavements has been developed by the city of Macon, Ga. For these repairs only a few simple tools are needed, states the Concrete Highway Magazine.

A hammer and chisel, tamper, hand float and shovel, cement and aggregates are required. The work can be accomplished by relatively unskilled labor under the direction of a competent foreman.

The excavation is first very carefully back-filled and the earth thoroughly compacted to prevent subsequent settlement. The edges of the pavement around the cut are trimmed to a depth of about 1 in. below the pavement surface to secure a vertical edge. This feature allows the patch to be finished without a slope or feather edge at the wearing surface and prevents spalling or disintegration around the edges of the patch. Below this trimmed edge the jagged walls are allowed to remain just as they were cut out, except that all loose particles are removed and the walls carefully cleaned of all foreign material and thoroughly wetted before concrete is placed in the hole.

A 1:2:3 mix is used for patching, being the same proportions as the mix in the original pavements, and as nearly as possible, the same kinds of aggregates are selected. The concrete is mixed by hand on the pavement near the hole. enough water is used to secure a plastic mix.

The cut-out section is filled from ½ in. to ¾ in. higher than the pavement surface and immediately tamped. After 15 to 30 minutes it is again tamped and this operation is repeated after another interval of from 15 to 30 minutes, the time between tampings being determined by weather conditions. Fresh concrete will not compact the entire thickness on first tamping, but after it has been allowed to stand for some time, the subsequent tampings will compress the material firmly against the walls of the old pavement. The importance of repeated tampings must not be overlooked, for it is this feature which is responsible for securing a perfect bond with the old pavement for its entire thickness.

The filled-in section is then finished with a hand float which is pressed down with sufficient weight to still further compress the filled-in concrete. By these repeated tampings and compressions, performed at a time when the concrete has lost some of its plasticity, the batch is worked and condensed till there is no further shrinkage of the material, and a perfect bond to the wall of the old pavement is secured, making the old and new sections practically monolithic. An absolutely smooth surface is secured by striking off the patch with a straight edge.

The patched section is cured by covering with dirt, wetted down at intervals, and is protected from traffic for four days.

The average cost of patches placed on concrete streets in the city of Macon by this method ranges from $3.50 to $5 per square yard, depending on the size of the patches.

Making Highways Ornamental As Well As Useful*

By JOHN A. HAZELWOOD.
Chairman, Wisconsin Highway Commission.

Of all the constructive work that is done, there is none that counts more in obtaining good results than the planning and preparation that goes before the actual performance. We realize that good roads lie at the basis of social institutions and the associational life of every community. Good and attractive highways can not possibly be obtained unless they are planned.

The period of achievement in the road work is not over, but we are entering upon new phases of the problem, mainly because we are seeing things in this motorized age in a different light. We are in a new era of social development and national growth and the question is not whether we shall continue to expand, but how we are to expand. On some things we have spent too much time and wealth and on others we have spent too little. Those things upon which we have wasted too much are easy to criticise because we see the mistakes, but those things upon which we have spent too little may have caused great losses, although they are not especially apparent. Wealth is produced not from the existence of natural resources, but from the conversion of natural resources into some form of human use. The aesthetic phase of road betterment does convert natural resources into forms of human enjoyment and should be encouraged.

It is not enough to build good roads, it is not enough to maintain good roads, it is vitally important when we build and maintain good roads that we beautify them. Roads without embellishments, such as trees, shrubs, and flowers, are ugly and prosaic. It is not enough to consider only the financial side of roads; it is our duty to consider as well the joy that man receives traveling upon them. Any progressive and self-respecting community ought not to allow a mercenary spirit to cause it to disregard the work of beautifying highways. Rural forces should make "Scenic betterment" one of their slogans. All over the New England States we find, in connection with trolley lines, comfort stations with trees, shrubs, and flowers about them, cared for at the expense of the railway companies. We find in many of our cities small parks with shrubbery and flower beds about the railroad depots. These companies do these things because they know they are rewarded for so doing. Rest rooms and comfort stations at regular intervals along the roads add greatly to the joy and comfort of traveling.

We have been careless and thoughtless in the past. We have permitted the woodman's ax to destroy the trees we have admired as bits of forest scenery.

Trees, Shrubs, and Flowers Along Highways.—We should plant trees, shrubbery, and flowers along our highways. What a splendid opportunity we have for getting good results from nut-bearing and fruit-bearing trees systematically planted and cared for along the public highways of this country. The expense of planting trees, shrubbery, and flowers along our roads and caring for them calls for only a small expenditure of funds. We should realize that each passing year will add to our pleasure if trees and shrubbery are planted and protected. Little do we realize the returns obtained from this class of service which are not considered in Wall St. or listed in Bradstreet.

We all admire a home with trees, shrubbery, flowers, and trailing vines about it. We know the pleasure that is excited in hearts by these adornments. We can not help but feel sorry for those who are obliged to occupy homes where no attention is given to plants, to flowers, and to trees. A little attention to flowers and trees will transform ugly lawns into spots of beauty. We can not look upon a beautiful tree or a cluster of shrubbery without forgetting a grouch and getting an inspiration for higher thinking. The shade and the freshness of trees along the roads running out of any village or city are needed now more than ever before. Concrete roads and hard-surfaced roads of all kinds are cold and need some softening effect.

Beauty and Utility in Road Building.—Beauty and profits usually do not go hand in hand. However, beauty is ofttimes combined with utility and this is true in road building. One can note at a glance whether a road has had the touch of an artist. A curved road is much better adapted to artistic landscape than a straight one. If to this curved road are added the touches of the tree, the shrub, the flower, we have pleasing associates as we travel along. It does not take a landscape gardener to tell whether thought and attention has been exercised in connection with highway construction.

We are all interested in civic art. We like to put our best foot forward. Civic art means a constant endeavor to secure in our public works the maximum of utility combined with the maximum of beauty. Cities have realized the importance of this and have given large attention to parks, playgrounds, and boulevards. In fact, proper attention to roadsides means a substantial addition to the value of adjoining property. Concrete macadam, and gravel roads particularly need the protecting shade of trees.

What Is Being Done in Road Beautification Work.—We know that many European countries have spent and are spending large sums of money in planting and caring for trees along the highways Many trees along highways are apple, plum and cherry, and from these large profits are annually obtained. The southern counties of the United States have given some attention to the matter of beautifying the sides of roads. The counties, particularly of Florida, have expended lots of money in beautifying their highways. Los Angeles County, Calif., spends annually $7,000 a year for the purpose of planting and taking care of roses along the highways.

The beautification of one country road in Los Angeles County has recently been completed. The road, which is known as the Sherman Way, extends 28 miles through an agricultural district near the city of Los Angeles. The district was originally embraced in a 47,000-acre ranch, which was taken over by a real-estate company, and about three years ago the work of beautifying the road was undertaken. It was completed last winter and the road formally turned over to the county, which in future will maintain it. The beautification has consisted of the planting of rosebushes and trees along the roadside. The rosebushes are planted at intervals of 7 ft. along each side of the road. The different varieties of roses are grouped together. In all, there are approximately 80,000 rosebushes. The total cost of this work was practically $100,000.

Many other counties in California are annually spending large sums of money in beautifying their highways. These investments are paying well, and the counties that have had this experience in beautifying their roads realize this and intend to continue to expend money on landscape work.

Neglect of Roadsides.—We have been a little careless in the road game of late. Many road builders have destroyed beauty by permitting the careless cutting out on the side of roads of the blackberry, the hazel brush, the wild rose, and the wild crab and thorn apple. The transformation of many roads by our so-called professional road builders from the rustic, beautiful drive to the barren highway seems almost brutal. In many cases everything has been grubbed out. Bare spots mark the places where beauty went up in smoke and flame. This change from the beautiful to the ugly has not been called for and should not have been permitted.

One distracting thing along the country highway is that of advertising. We see the billboard destroy the beauty of many pretty glens and beautiful curves. The greed of advertisers has destroyed many beauty spots by putting up advertisements. This destruction of beauty has been somewhat handled through city ordinances issuing permits or licenses. Women's clubs in our cities have done much in the matter of curbing landscape destruction by billboards. Little has been done in rural districts to restrict such advertising.

It seems that the most effective way of handling the question is the exacting of a tax. I believe we could drive away much of our advertising on billboards that can reach the eye of the traveling public. In order to not be unduly hard on those who have already erected their billboards, half or quarter the rate may be charged them until they take them down or have them repainted. This is one of the effective ways of handling this manner of destroying the beauty of our highways.

Need of Landscape Artist.—Every highway commission should employ a landscape artist. Delaware has already taken that step. There should be a landscape artist abroad in the land. Nothing counts like expert advice and direction in the handling of important problems. We can not afford to let this matter of rural planning continue to be worked out under our indifferent amateur policy if we wish to make our roads ornamental as well as useful.

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*A paper presented at the last convention of the American Association of State Highway Officials.

We all enjoy a beautiful road and drive. Nothing is more pleasing to pass over than a road stretching ahead, running by farmhouses, wayside schools, churches, and villages. The automobile has crowded two, three, and even four hours into one hour as compared with the horse-drawn means of transportation. A road seems to have moods and whims. Sometimes it stretches on and on onto infinite space; sometimes the eye loses it in some wistful curve; sometimes it loiters in sunny vale.

Some one said, "The important thing to me about a road, as about life, is not that it comes from somewhere and goes somewhere, but that it is livable where it goes." The invitation to explore the unknown road is very alluring. The unknown road as it winds along is a perpetual revelation of beauty. One person rightly says that he greets a new road with almost as much pleasure as a new person and usually parts with it with rather more reluctance. It is curious, indeed, how closely roads are linked with humanity; how warmly companionable they are. A public road talks business all the time. It tells us new things about everything that appears in a panoramic view on the roadside. It tells about the farm homes and the type of farming that is being carried on by the owners. It is one of the most important and interesting of all of man's wonderful institutions.

Beautiful Roads Are Silent Educators.—We never receive our friends in our woodshed and break bread with them in a corner of the kitchen, using our ordinary linen, silverware, and dishes, but we receive them and entertain them in the most comfortable rooms in our home. We dine them in our most pleasant room and we use our best linen, silverware, and dishes. What for? Why, for the very purpose of impressing upon them that we are maintaining good homes. Our visitors are usually our friends. They bless us and make us happy and contented. Therefore, we are justified in spending a great deal of time and money in providing attractive lawns, beautiful entrances, and pleasant homes. The portals, the gateways, the entrances to our community homes are the highways.

Many of our cities understand the value of having inviting boulevards and streets for guests to enter. Large attention is given to the main entrance to commercial and residential centers. They beautify the streets with park rows, with trees, hedges, shrubbery and flowers so that visitors may feel more welcome. Rural communities should take the same interest in their roads. They should not only build and maintain roads but they should beautify them to give their friends a good impression of their homes.

We find many so-called self-styled "practical men" who do not realize the importance of beautifying country highways. Lloyd-George said that there is nothing more fatal to a people than it should narrow its vision to only material things. We need beautiful streets and highways to stimulate the imagination and exalt the vision of our people. We know that good roads mean good schools, education, and prosperity and that bad roads mean poor schools, ignorance, and poverty. Beautiful roads are silent education. Each beautiful thing makes a good and lasting impression upon the plastic mind of man, and when we consider that an ugly road makes the opposite impression we should realize our responsibility in the matter of adornment of our highways.

Asbestos Bitulithic Pavement.—A new pavement in which asbestos fibre is combined with mineral aggregate was mentioned by Mr. George C. Warren, president Warren Bros. Co., in an address May 1 before the Highway Engineering Class of the Valparaiso University. The pavement was invented by August E. Schutte, chemist of the Warren Bros. Co., and a patent application was filed in the year 1916. The patent was granted in 1918 for a pavement and method of laying same, using asbestos fibre combined with mineral aggregate along certain scientifically determined lines. Owing to difficulty in securing economic supply of asbestos under war and post-war conditions, the general introduction of this construction has been deferred, but sample demonstration areas have been laid during the past three years in several sections of the country, particularly under the rigorous climatic conditions of New England. One commercial contract was executed in New Bedford, Mass., in the year 1919.

Calculation of the Vertical Curve

By JOSEPH A. KITTS.

The following routine of calculation of the vertical curve is based on the approximate application of the parabola as given in Searles' "Field Engineering."

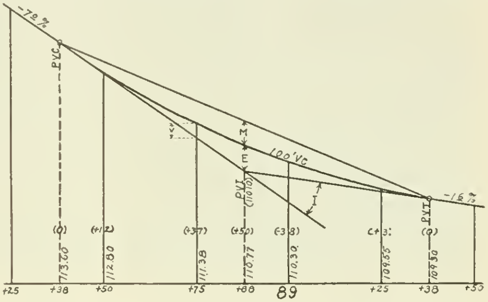
The basic assumptions in this application of the parabola are:

(a) The vertex of the curve is midway between the point of intersection of the tangent grades (PVI) and the cord connecting the ends of the curve, i. e., E = M. (See equation (2).)

(b) The vertical offset (v) of the curve from the tangent grade at any point varies as the product of E into the square of the fraction, distance of point from nearest end of curve over one-half curve length. (See equation (4).)

The foregoing assumptions are practically correct for all ordinary conditions of grade and length of vertical curve.

This application of the parabola is, undoubtedly, the most simple method of constructing vertical curves on railroad and highways. It is flexible and, with a system of calculation eliminating unnecessary work, is as fast as any method, applicable to general use, which has been devised. The system of calculation presented is free of unnecessary work.



(1) $\text{El. PVC OR PVT} = \text{El. PVI} + \text{gradient (curve length /2)}.$

$$\text{(2) El. Vertex of Curve} = \frac{\text{El PVC} + \text{El. PVT} + 2\ \text{El.PVI}}{4}$$

(3) $\text{E} = \text{External} = \text{El. Vertex} - \text{El. PVI} = \text{M}$

$$\text{(4) Vert. Offset, } v = \text{E}\left\{\frac{\text{Min. Dist. to Curve End}}{\text{One-half Curve Length}}\right\}^2$$

(5) $\text{Elevation of any point} = \text{El. PVC or El. PVT} + \underset{\text{(nearest end)}}{\text{gradient}}$ x (Distance end of curve to point) + v.

The foregoing are the minimum number of operations required. The following practical example is given to more clearly show the system of calculation:

Given: A grade of — 7.0% intersecting a grade of — 1.6% at Sta. 88/88 and elevation 110.10. (See Fig.)

Sought: Elevations of stations, as listed, for a 100 ft. vertical curve.

	Sta.	Distance curve end to station.	Elev.	
—7.0%				
PVC	88+38	0	113.60	
	+50	+12	112.80	
	+75	+37	111.38	
100'VC	+88	+50	110.77	PVI (El. 110.10)
	89	—38	110.30	
	+25	—13	109.55	
PVT	+38	0	109.30	
—1.6%				

(1a) El. PVC, Sta. 88+38=110.10+0.07 (50)=113.60.
(1b) El. PVT, Sta. 89+38=110.10—0.016 (50)=109.30.
(2a) El. Vertex=(113.6+109.3+2 (110.10))/4=110.77.
(3a) E=110.77—110.10=0.67.
(5a) El. Sta. 88+50=113.60—0.07 (12)+0.67 $(12/50)^2$=112.80.
(5b) El. Sta. 88+75=113.60—0.07 (37)+0.67 $(37/50)^2$=111.38.
(5c) El. Sta. 89+00=109.30+0.016 (38)+0.67 $(38/50)^2$=110.30.
(5d) El. Sta. 89+25=109.30+0.016 (13)+0.67 $(13/50)^2$=109.55.

In equations (1) and (5) it is necessary to observe whether the grade and offset changes are plus or minus. The best rule is to visualize the direction of these changes.

The length of vertical curve may vary to suit the conditions. Where the difference in gradients is slight the curve must be long to give appreciable offsets from the tangent grades. On the other hand, where the difference in gradients is extreme, the curve must be long enough to avoid too abrupt change.

As the vertical curve (parabola) approximates the circle closely, the radius of curvature may be calculated readily as for the circle. The tangent of the intersection angle is approximately equal to the algebraic difference of the gradients, or, in the above example, $\tan I = (-0.07) - (-0.016)$ appx. $= -0.054$. $R = L/\tan$ (appx) $= 1850$.

A suitable length of curve for highways is expressed by $L > 1000 \tan I$.

Regulation of Highway Motor Transport*

The matter of granting franchises and regulating highway motor transport has become so important that I have selected five states in which this matter has come up within the past few months. Regulation by state commissions of any development is so important that it should have our undivided attention because it can, in the very beginning, make or break any economic development which is struggling for a foothold.

About a year ago a man began the operation of a motor express line, carrying food between New York City and Long Island points serving about 130 towns along the south and north shores of Long Island. This man started with two trucks and built up a business until he had a cash investment of $40,000, operating about 10 trucks. Surely this line was a great benefit to the communities it served, and yet he was forced out of business on account of indiscriminate cutting of freight rates by irresponsible truck operators who must have known that sooner or later the business built up by this man would wind up its affairs in bankruptcy and that they, too, unless they received proper compensation for their services, would only meet with a defeat which faces all men who try to accomplish the impossible. Had this man been protected by a franchise from piratical operators who entered his territory, not from a standpoint of service, but with the idea of destroying the business he had built up, this line would have remained in business and continued to serve its patrons.

Regulation of Motor Transportation in Western States.—The states that have taken a stand in the regulation of motor transport lines are California and Nebraska. Highway transportation in California is under the jurisdiction of the State Railroad Commission.

We find recently two instances where franchises were granted to highway transport companies in the face of protests filed by the Southern Pacific Railroad and the American Railway Express against the granting of such a franchise to the Santa Barbara Motor Express, designed to operate between Los Angeles, Santa Barbara, Santa Paula, and Ventura, and another line formed to operate between Santa Paula, Ventura, Santa Barbara and intermediate points. The Southern Pacific R. R. and the express company claimed they were giving adequate service between the points which the motor companies anticipated serving, and stated that the motor transport companies would be unnecessary competitive lines. The State Railroad Commission gave its opinion as follows:

> We are of the opinion that the public desiring transportation of freight and express between Santa Barbara and Los Angeles and intermediate points is entitled to a more expeditious service than that of present being given by the Southern Pacific and the American Railway Express. Notwithstanding the evident ability of the Southern Pacific Railroad and American Railway Express to give adequate service, there is evidence that the average freight shipment is in transit from three to four days before delivery is effected, and that approximately 36 hours are required to effect delivery when shipments are forwarded by express. This is in face of the fact that scheduled express time between terminals is approximately 3½ hours, and scheduled freight time between the same terminals is approximately six hours.

Motor Transport in Pennsylvania.—The following statement issued by the Public Service Commission, will tend to show that this commission is dealing very fairly with all applications:

STATISTICAL STATEMENT OF AUTO-BUS AND AUTO-FREIGHT LINES APPROVED BY THE COMMISSION.

Applications approved by the Commission	435
Ceased operating as disclosed by survey in the latter part of 1918	97
	338
Certificates surrendered and revoked	7
Of this 331, 17 are auto-express and freight lines.	
In addition to the above, 15 auto-bus lines and 5 express and freight lines operating prior to the effective date of the Public Service Company law have filed rates in accordance with the rules of the Commission	20
	361
Total individuals, corporations and companies operating auto-bus and auto-freight lines to date	338

PENDING.

There are now pending before the Commission 122 applications for right to operate automobiles as common carriers. 74 of this number are applications for right to operate in Philadelphia.

Nebraska Fixes Rates for Highway Transport.—Motor transportation in the state of Nebraska has made such rapid advances that the State Railroad Commission, located at Lincoln, undertook to formulate rates for highway transportation companies, as shown under its General Order No. 46, Supplement B. issued No. 26, 1919, and effective Dec. 8, 1919, entitled, "Highway Trucking Rates."

In its survery of the state, it investigated cost systems employed by various transport companies in the operation of motor trucks over the highways and drew up a freight classification list placing various types of freight under four classes, describing 103 items covering different kinds and types of merchandise. It has compiled rates for first, second, third and fourth class matter, first class being 20 ct. plus 1½ ct. per mile per 100 lb., the second class rate being 85 per cent of the first class rate, the third class rate 70 per cent and the fourth class rate 60 per cent. Rules and regulations, standard bills of lading and other forms are provided by the commission for the management and operation of a highway transport line. As most lines are charging 1 ct. per mile per 100 lb., the rates allowed by the State Railroad Commission are considered fair.

Proposed Rates in Colorado.—Colorado undertook to place highway transportation under the supervision of the Public Utilities Commission, but this failed to pass the state legislature and therefore the rates compiled by it never became operative. However, it might be well to call attention to them. Rates were formulated for highway transportation operating in what was termed the "Prairie Division," while another set of rates were made for motor truck operation in what is known as the "Mountain Division." In the former, the minimum charge per shipment was 25 ct., where as in the latter it was 30 ct. Motor trucks operating in the "Prairie Division" charged a rate of 30 ct. per 100 lb. for 5 miles, and for distances above 5 miles up to 100, the rates graduated 5 or 10 ct. for each additional 5 miles until they reached $1.00 for 100 miles. In the "Mountain Division" the rate for hauling 100 lb. 5 miles was 36 ct. and this graduated until it reached $1.20 per 100 lb. It is stated that these rates were formulated upon a consideration of the known factors affecting motor truck transportation in Colorado, including extended studies of actual observations of costs of hauling one and two-ton units. The Public Utilities Commission stated that the scales are placed at the disposal of prospective operators and were not to be considered mandatory in any sense, being designed primarily for the use of rural lines where no railroad service exists, as where such service does exist, the freight and express rates generally will determine the motor rates.

It is hoped that regulation by State Commissions will encourage the advancement of highway transportation and that the commissions will set forth in their decisions the dangers which may be encountered when an operator undertakes the organization of a line in a certain territory, thereby guiding this infant industry until it is able to stand on its own solid foundation.

Paver Lays 5,000 Brick Per Hour.—In paving the Prunytown Pike, near Grafton, W. Va., according to Successful Methods, John W. Martin, a Negro, laid 600 lin. ft. of 16-ft. brick road in 8 hours. In doing this he placed 42,000 brick weighing 10½ lb. each. He was served by 22 convict laborers carrying brick and by laborers placing brick on carrying boards. On Armistice Day, working on a street in Grafton and limited by lack of sufficient carriers, he placed 15,000 bricks in 2 hours and 40 minutes. It is stated that he can at any time place 90 bricks in 30 seconds.

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*Abstract of a report of F. W. Fenn Chairman of the Committee on Highway Transport Franchises of the National Highway Traffic Association, presented Jan. 29 at the annual convention of the National Highway Traffic Association.

Methods and Cost of Constructing 12 Miles of Monolithic Brick Pavement

By F. A. CHURCHILL.

In the summer and fall of 1919 the main highway crossing the northern tier counties of Ohio was paved with brick for a distance of 11.92 miles from Ashtabula to Conneaut, at a cost of $421,000 for the driveway plus $63,000 for a 2-ft. concrete gutter on one side. The pavement was 16 ft. wide on ordinary stretches and 18 ft. wide on super-elevated curves. Monolithic construction was specified—6-in. concrete foundation, 1:3:6 mix, and 4-in. wire-cut lug brick laying 40 to the square yard. A 1:1½ cement grout filler was used. The job required about 4,500,000 brick. The average haul from siding to job was two miles. The average cost of hauling by motor trucks was $4.20 per 1,000, or approximately 11 ct. per square yard of pavement. The cost of the brick piled along the roadside (not including plant cost) was $10.70 per 1,000.

Preparing Subgrade and Placing Forms for Monolithic Brick Construction for Ashtabula-Conneaut Highway, Ashtabula County, Ohio.

Constructing 2-Ft. Concrete Gutter With Small Mixer.

Cement and coarse aggregates for concrete were delivered by an interurban railway which parallels the road the entire distance from Ashtabula to Conneaut. Water for mixing concrete was pumped through pipe lines from a small lake situated about midway between the two cities.

Two complete outfits and two crews were employed on the work. Work began at the central point and the gangs worked in opposite directions. Two Parrish automatic tamping templates were used in shaping and tamping the concrete foundation.

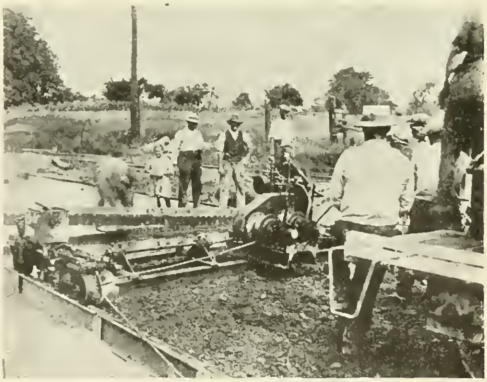
These details are of interest in that they indicate that both natural conditions and equipment were favorable to economical construction.

Each gang built the entire pavement from sub-base to finished grouted surface as it went along. The daily average per gang was 550 lin. ft. of completed pavement, although one of the gangs made a record of 630 lin. ft. or 1,236 sq. yd. in an 8-hour day.

Construction progressed at the rate of from 800 to 1,200 sq. yd. per day for each outfit, at a manipulation cost of from 18 ct. to 29 ct. per square yard. The rapid rate of progress was attributed by the contractor to the Parrish automatic tamping template which had a working capacity greater than the capacity of the big power mixer to deliver the concrete.

The 2-ft. concrete gutter was placed at the rate of 1,200 lin. ft. per day, with a mixer, a mixer man and 18 laborers.

The highway was completed in 92 elapsed working days, although not 92 days of actual work was done. One mixer worked every day on which any work was done, but the other mixer worked only 57 days.



Parrish Automatic Smoothing and Tamping Template Preparing Concrete Foundation. Bricks Were Laid Directly on Green Concrete Immediately Behind Template.

Thomas P. Fitzgerald, the contractor, submits the following details of gang organization, together with an itemized statement of wages paid for an 8-hour day:

No. of men.	Total.
2 foremen, $5 per day	$10.00
22 shovelers and wheelers, $4.50 per day	99.00
5 cement handlers, $4.50 per day	22.50
4 brick men, $5 per day	20.00
2 men behind mixer, $5 per day	10.00
10 laborers carrying back, $4.50 per day	45.00
2 mixer men, $5 per day	10.00

1 roller man, $5 per day	5.00
1 foreman, $7.50 per day	7.50
Total cost of gang per 8-hour day	$229.00

Two organizations of this kind were employed at a labor cost of $458 per day. On this per diem basis, the labor cost for construction of pavement only was $42,136. These figures do not include preliminary work or the cost of hauling brick and other materials and preparing subgrade, nor the cost of constructing the earth berms or shoulders alongside the pavement.

In round numbers that are substantially accurate, 12 miles of 16-ft. brick slab representing 112,600 sq. yd. of monolithic pavement, cost $421,000, or $3.74 per square yard. The actual length of pavement was 11.92 miles, and the cost was $35,318.71 per mile for pavement proper, or $40,604 per mile including the 2-ft. concrete gutter.

First Coat of Grout on Monolithic Brick Highway.

The general attitude of contractors toward road-building contracts was indicated by the fact that the state highway department advertised this road several times, and Fitzgerald was the only bidder at the final letting. He estimated that he saved 15 ct. per square yard by using Parrish automatic templates and monolithic construction instead of cement-sand construction and manual labor on the foundation.

Rapid Increase in Use of Motor Trucks by Eastern Farmers. Figures obtained by the United States Department of Agriculture in connection with the investigation of the use of motor trucks by farmers indicate that the rate at which eastern farmers have been adding motor trucks to their farm equipment has increased rapidly during the last three years. Reports gathered by the Office of Farm Management from approximately 1.000 farmer truck owners in the New England States, New York, Pennsylvania, New Jersey, Delaware, and Maryland during January and February, show that at that time over 80 per cent had owned their machines less than three years. The length of time 955 of these men had owned their machines is as follows: Less than one year, 373; more than one year but less than two, 237; more than two years but less than three, 181; more than three years but less than four, 86; more than four years but less than five, 37; more than five years, 41. These reports were all from farmers who had purchased new trucks for their individual use. Reports on secondhand machines and on truck attachments for pleasure cars, as well as trucks used primarily for custom work or on regularly established routes, were not included in the count. While it is impossible to determine just how many of the trucks which have been in use only one or two years were purchased to replace other trucks worn out or discarded, it is known that a large percentage of the reports covers first experience with trucks.

Working Speed of Tractor.—It is an established fact states the April Report of the Nebraska Department of Public Works that the working speed of horses is from 1½ to 2 miles per hour, while the working speed of a tractor is from 2½ to 3½ miles per hour.

Taking Care of Traffic During Construction*

By C. R. WEYMOUTH,

Division Engineer, Wisconsin Highway Commission.

What conditions justify closing the main traveled road thereby forcing all travel to take to a secondary road? My answer to this is: "Only when there is no other possible way out and then for the briefest time possible. In other words, only for a concrete paving job or a bridge job which it is impossible to bridge around temporarily.

I wonder how many have ever stopped to think what it costs the public to be forced to detour and to travel one mile, for example, farther than they would have to travel on the main road. There was a case in my division last summer when a main traveled road was closed for 30 days. The detour was three miles in all around this mile under construction. Travel was thereby obliged to go two extra miles. This road was traveled daily by 1,000 cars. The expense per mile of travel was undoubtedly 10 ct. Therefore, the 1.000 cars traveled for each mile of detour 1,000 miles at a cost of $100. At least 1,000 of these cars were driven by men on business or whose time was worth, say, $1 per hour. Each traveler lost four minutes in driving over each mile of detour at the rate of 15 miles per hour. The expense to the public in additional mileage alone per day was nearly $100 per mile. The total loss per day for this 3-mile detour, two miles of it being lost travel, equals $200. The road was closed 30 days, or cost to the public amounting to about $6,000, not including lost time of drivers.

I investigated the amount of funds being expended on this mile, and found that it totaled $2,000 for building three or four culverts, doing some grading and graveling. Therefore the long-suffering public to get a $2,000 improvement was forced to lose $6,000 in extra mileage. If we add the factor of lost time, this detour caused a greater loss.

The County Highway Commissioners and foremen should realize that a sense of values is necessary in considering when a road should be closed and when it should not. There are many jobs being carried on in this state, particularly the grading, graveling and culverting jobs, where if the foreman of the crew wished to do so, he could so carry on his work so that the public could go through. For some reason foremen always have a tendency to close up a road if they can think of a possible excuse for doing so. I realize that it does slow up the work to have cars go through. It slows up the work to have to carry it on if the road is always passable. I also admit freely and frankly that the public does not seem to appreciate these favors. They go through on these jobs at the highest rate of speed that they can possibly go through on without regard to safety of life or limb of men or teams employed on these crews. The public does seem to be speed mad and some drivers apparently like to see how close they can come to a team or a road grader without hitting him. This, of course, irritates a foreman and they feel that they are not entitled to give any favors to the public, but in the long run even the most reckless driver will gradually realize that it is up to him to meet these favors half way.

It is not a tremendous job to bridge over temporarily a 6-ft. or 10-ft. creek while a bridge over that stream is being built so that the public can go through. If the "I" beams of timbers of the old bridge cannot be utilized for this temporary bridge, timber should be bought for a new temporary bridge. I know that lumber costs about $60 or $70 per M. ft. in this part of the state right now, and it seems like a big expense to build such a bridge. A temporary 10-ft. span bridge with heavy stringers will cost about $100 to $150 at the most, but then every mile of detour is costing the public from $50 to $100 a day.

Upon important roads temporary bridges should be built around even the 50 and 60-ft. bridges. We should even go to the trouble of putting in several timber bents or a trestle to carry the bridge. We have allowed culverts on important roads in my division in certain cases to be built one-half at a time in the past season, one-half the excavation being made and the half culvert built, and then after a wait of a week the other half being built. The steel reinforcement of the first half was naturally arranged to project into the second half and the contractor was obliged to put in a few extra 4-ft. rods at the joint for the privilege of building one-half at a time. This allowed travel to go in constantly and stay on the old hard road.

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*From an address presented at the last annual road school of the Wisconsin Highway Commission.

Guiding signs should be displayed in great frequency on detours. There should be a very large detour sign about 3 ft. to 5 ft. at the beginning of a detour with an unmistakable barricade of some sort to turn traffic. Many times a sign is put up at the beginning of a detour in such an indefinite way that it is left optional with a driver to take a chance and go through on a main road. A man may take this chance and have to turn back a mile or so farther on. This is not right. A detour should be unmistakable. The sign should be arranged so that an impression is left on the driver's mind that is absolute and final that the road is closed if it is closed. If the road is under construction, but passable, say so. If it is closed and impassable, say so. It is very important to mark the ends of culverts on detours with a white post. The culverts are almost always dangerously short on these detour roads when traffic goes onto them Before sharp turns put up a danger sign, they are mighty important. Before high, narrow fills be sure that a warning sign is put up, especially if it is such a width that two cars can barely pass on it. As this is the most dangerous of all, this sort of a fill should be widened out 3 or 4 ft. as rapidly as possible.

Illinois System for Signing State Bond Issue Highway Routes

Concrete signs have been adopted by Illinois for marking the state bond issue highway routes. The head of the post is 4 in. thick, 2 in. wide, and about 20 in. high. It is made of concrete, using a white cement. The outline of the state is grooved into the post, and the outline then is painted black. On the face of the post at the top appears the number, indicating the number of the state bond-issue route as fixed by law. A red figure indicates the location of this marker on the system, and this same number will appear on the state map, which ultimately will be completed which will show the location of that particular point on the map. The red figure tells a dual story. It serves to locate the point in the field with reference to the map for the convenience of the tourists, and also indicates the approximate mileage from the eastern and northern terminals of the route. At the bottom appears the letter "L" or "R," the convention sign for turn to the right or left. These posts have a total height of 8 ft., are embedded in the shoulder of the road adjacent to where the ditch breaks off, to the extent of 3 ft., so that the post stands 5 ft. above the ground, just where the vision of driver will naturally catch it, also where a headlight will pick it up at night.

Cost of Street Cleaning at Cincinnati, O.—The following tabulation from the 1919 report of Fred Maag, Superintendent of Street Cleaning of Cincinnati, O., shows the comparative unit costs in the street cleaning functions, rubbish and ash collection for the years 1916 to 1919 inclusive:

	1916		1917		1918		1919	
	Unit cost.	Unit cost with overhead.	Unit cost.	Unit cost with overhead.	Unit cost.	Unit cost with overhead.	Unit cost.	Unit cost with overhead.
Flushing, squares.	$0.119	$0.241	$0.121	$0.268	$0.120	$0.274	$0.131	$0.284
Street sweepings, cu. yd.	.270	.476	.286	.526	.332	.633	.365	.674
Ash collection, cu. yd	.282	.468	.299	.515	.344	.613	.375	.638
White wings, 1,000 sq. yd.	.305	.352	.301	.247	.313	.360	.328	.380
Broom gang, squares	.243	.295	.238	.282	.264	.305	.241	.283
Gutters, squares.	.136	.153	.144	.162	.138	.155	.178	.199
Gutters after flushing, squares ..	.136	.151	.140	.157	.167	.187	.169	.189

Right of Way Marks of Alabama Highway Department.—The Alabama State Highway Department erects simple concrete right of way markers at the P. C. and P. T. and on long tangents, at intermediate points on the sands. These markers are placed right on the border of the right of way. The marker is about 5 ft. in length, 8 by 8 in. at the bottom and 6 by 6 in. at the top, with the letters "R. W." sunk into the upper part. It stands out of the ground about 2 ft.

Relation of Tractor and Trailer Traffic to Highway Design*

By H. ELTINGE BREED,

Consulting Highway Engineer of New York City.

Tractor and trailer is a sure thing. It is here to stay. There are registered in the country today 35,000 trailers. That is definite. So is their percentage of increase in the last two years—over 100 per cent. At this rate of increase we can plan for 500,000 or more tractors and trailers by the year 1930. The only uncertain factor is whether the rate of increase will itself increase, and how much. I personally believe that we should plan for at least double the number of tractors and trailers given above.

The crux of the economic situation as I see it in this country today is, even more than production, distribution; distribution of the products of the soil, of labor, of machines; and fairer distribution of the wealth that accrues from these products. The motor truck and the tractor and trailer have been developed to meet the need of distribution.

The railroads cannot meet this need. Whatever relief we get this year and next will be from motor transportation.

Much as we need distribution we need even more economy in distribution. Motor power for short-haul freight does effect such a saving. That, I believe, is the great reason for its rapid growth. Mr. Banham says, "I find that if we combine all the costs, such as additional crating, labor, etc., to make a less than carload shipment, the rate averages a dollar a hundred from Yonkers to Newark. If you take the same movement by motor trucks or tractor and trailer, with decreased boxing, weight and labor, the rate averages 20 ct. For 12 miles, then, there is a difference of 80 ct. per 100 lb. in favor of the motor truck. The saving in time, in space for storage, in materials, are all in favor of transportation by motor."

But in the uncertainty of highway design, motor transportation suffers a serious check. I say "uncertainty" because this spring improved roads have gone to pieces as they never have before. The Lincoln Highway between Trenton and Philadelphia has completely broken up. Some people say that the damage is due to the hard winter. That I disbelieve. Weather is a natural process that should not hurt a healthy, protected organism, either human or highway. The roads are organically wrong, because they are not designed for the loads they must bear. Unless they can sustain the necessary traffic they do not fulfill their function. They hinder, instead of help, distribution. The savings effected by motor transportation more than offsets the cost of the roads that are essential to this transportation. The economic value of good roads to the country cannot be expressed wholly in terms of the dollar.

Adequate design of highways for tractor and trailer traffic, means an immediate provision for three lines of traffic near all large cities and on all trunk routes, with possibility of an added 10 ft. longitudinally for the fourth line. For each line of traffic at least 9 ft. should be allowed. The additional width is necessary because tractors and trailers move at a speed of from 6 to 12 miles an hour, and other cars, going from 12 to 40 miles must have room to pass.

Turns must be widened because of the greater length of the tractor and trailer, and curves must be super-elevated in order that they may keep in their own line of traffic.

With the increasing cost of motor fuel, special attention must be given to reducing grades. The consumption of gasoline increases directly with an increase in grade. On a fairly level road you can haul a heavier load for less fuel. This saving on main roads heavily traveled often compensates in two or three years for whatever additional cost is involved in reducing grades.

Because of the distribution of load over 6 to 8 wheels, and because of their slower movement, tractors and trailers are less hard in impact upon pavement than heavily loaded trucks. They would not require any greater strength of foundation or better type of surfacing than we would provide for regular heavy traffic, but all heavy traffic requires an adequate foundation and a durable type of pavement. A semi-durable pavement for heavy traffic is sheer waste.

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*Abstract of a paper presented May 13 during the annual meeting of the National Highway Traffic Association in New York City.

Trestle Unloading and Storage Arrangement for Aggregate for Concrete Road

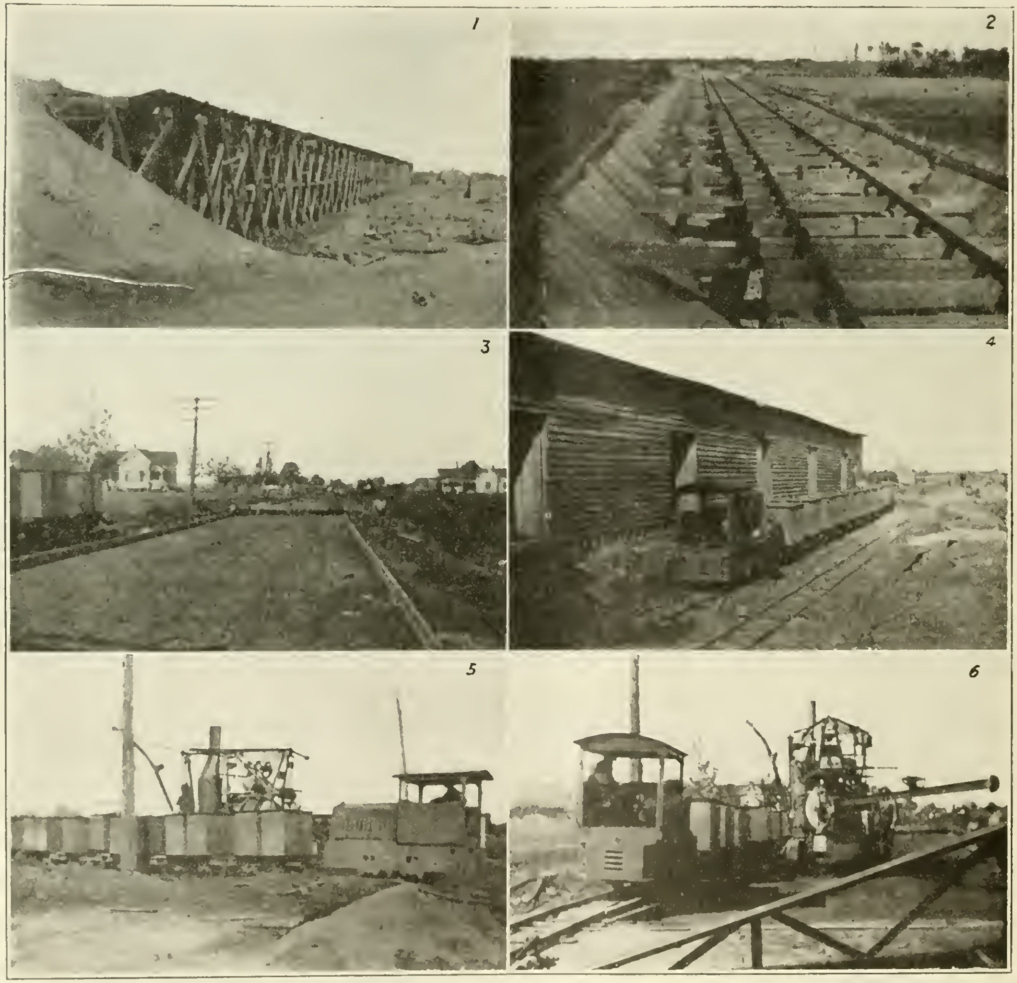
An excellent example of a road building plant layout designed to meet local conditions is given on the 6.6 mile concrete road contract of the W. Z. Williams Co., Inc., Macon, Ga., at Finley, Ga.

The M. & B. R. R. crosses this highway at right angles, at approximately the center of the work and thus was available as an unloading station, with one set-up of the plant. The topography of the ground is such that it was possible to carry the siding to a trestle 540 ft. long, under which bins providing storage capacity for 4,000 tons, have been placed, with separate compartments for sand and stone. There was plenty of local timber and the contractor had a small portable sawmill working in the neighborhood.

This arrangement, it will be noticed, does away with all unloading equipment and labor. The material is dumped from Western 12-yd. standard gage bottom dump cars from the trestle directly into the bins. Under the bins is a 24-in. gage track, on which Western batch boxes and Western road builders' trucks are operated, drawn by a Whitcomb 6-ton gasoline locomotive. The materials thus drop directly into the batch boxes from the bins.

Cement in bags is unloaded into a cement house, built between the standard gage spur and the industrial track leading to the trestle. Loaded trains of batch boxes from the trestle on the way to the mixer stop at the cement house for the proper amount of cement. As the floor of the cement house is built on a level with the top of the batch boxes loading is a simple matter.

A Koehring 4-sack paver with standard crane attachment completes the handling of the batch by dumping the batchboxes directly into the mixer skip. None of the materials used on this job touch the ground, even for storage, until they are run through the mixer and placed on the subgrade.



(1) Unloading Trestle for Stone and Sand. (2) View From Top of Trestle Showing Bins. (3) Subgrade Preparation With Lakewood Subgrader. (4) Cement House. (5) Batch Boxes Being Unloaded at Mixer. (6) Mixer; Part of Finishing Machine in Foreground.

Texas Lets $8,000,000 of Road Contracts.—Since the beginning of the year, the Texas State Highway Department has approved contracts for construction of 553 additional miles of the state system of highways. The cost in round numbers amounts to $8,000,000. The mileage of the different types represented in these contracts are: Concrete pavement, 41 miles; bituminous pavement, 162 miles; crushed rock or gravel surface, 267 miles; shell, 10 miles; grading and permanent structures, 73 miles.

Nebraska Using Convict Labor in Building State and Federal Aid Roads

Nebraska is now using convict labor to construct road projects in Johnson, Seward, and Pawnee counties. This is the first attempt to use such labor since 1915, when the state contracted with the State Institution to build a portion of the road extending along the State Agriculture Farm School in Lincoln.

The plan is described in the May monthly report of the State Department of Public Works. During the week of April 5 to 9, the Department of Public Works decided because of the excessively high prices on earth excavation, to reject all bids on the Federal and State Aid road projects in the above mentioned three counties. These roads are: Project 60A, St. Paul Bridge, South; 7.58 miles in length; Proj. 134, O. L. D. in Seward County; 9.72 miles; Proj. 48, Tecumseh-Crab Orchard, 13.85 miles; Project 97A, Table Rock Lewiston; 15.7 miles; and Project 128 Seward-Lincoln, or the S. Y. A. highway, 7.18 miles in length.

It was estimated that with the present equipment and organization, the State Department, by using convict labor can take over the contract for the four propects at estimated prices. Culvert contracts were let, and the state work will consist only in bringing the road to grade according to specifications.

It was decided to start the camps as soon as housing facilities could be provided. Consequently, a contract was let for the construction of sleeping rooms, diner, kitchen, and lounging houses, for the four camps. It is estimated that the cost of each outfit is somewhere in the neighborhood of $500; this includes the wagon bed.

The houses are 20x9 ft. and have sufficient lighting and ventilation. The diner has a built-in table in the center of it, around which are benches. The kitchen is equipped with built-in cupboards, a 6-hole range, work tables, etc. Although figures for the entire amount of the equipment of the camps are not available, it is estimated that $450 will cover the cost of each camp equipment. This includes the costs of dishes, blankets, mattresses, etc., for each of the six houses.

On May 5 the first prisoners left the State Institution for Camp No. 1 at Tecumseh, to begin the construction of 14 miles of road. Equipment of all kinds, such as horses, graders, carts, etc., was on the project, and work will be started as soon as the prisoners arrive.

Each camp will have 18 men, a cook, and two supervisors, one for day and one for night duty. The prisoners will work 10 hours per day, but not on Sunday. It is the policy of the Department to see that the food is well cooked, and served in good amounts and in good condition. Special attention has been given to the selection of the cooks. Reading material will be furnished the men, and as many comforts as possible given them.

Each prisoner will receive $1.50 per day for his work, with board, while the State Institution will receive 75 ct. per day per man. This means that the Institution will be getting $4.50 per week per man, or approximately $72 per week from each of the camps having 16 men at work. At this rate each prisoner will be credited with $9 per week from the state for 60 hours' work, or at the rate of 15 ct. per hour. The cooks and supervisors will be paid from state road funds.

When the men were chosen, their prison records were carefully checked over, and the offense, and term of years to be served, were considered in each case. The majority of those chosen were convicted for minor offenses, and are serving short terms; however, a few are serving long terms.

The prison garb has been discarded, and the men will work in civilian clothes. Although this is not the practice in a large number of states, it was thought best to try out the men on an honor system, by giving them the responsibility for the conduct of the camp. Before the men were sent out they were told that they were to be sent out on their honor, and that a man who violates the rules laid out for the camp not only brings reproach upon himself, but upon all the inmates of the Institution.

The rules governing the camps are as follows:

You shall obey all orders from the supervisors of the camp.

You shall not leave the camp after work in the evening, unless in the company of the supervisors. This also includes Sundays and days when there is no work.

Refrain from any profane language.

You shall be ready for work at the time set each morning.

Anything you may need in the way of tobacco or clothing you shall report to the supervisor.

No gambling is permitted, however there shall be no objection to checker boards.

No cigarette smoking will be permitted in camp.

For writing material and stamps, you will see the supervisors.

Each man will be held responsible for the treatment of his team, and no brutality will be tolerated toward any of the animals in the camp. The best of care must be taken of the teams and the equipment.

Each man shall look after his bunk, and see that it is kept clean and in good condition.

The hour for retiring shall not be later than 9 o'clock.

There shall not be any promiscuous visiting with strangers.

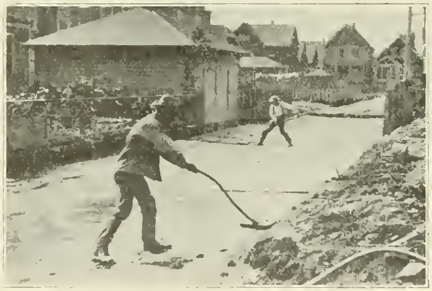
This camp is an honor camp, and there shall be no boisteronsness nor rowdyism carried on. It is sincerely hoped that those in whom confidence has been placed, will be faithful to the trust, and that it will not be necessary to return any of the men from Camp. No. 1.

The future of the road building by prison labor and the success of the project depends largely upon the deportment of this first camp. The men in charge of the camp are looked upon as supervisors, and they are empowered to enforce all rules, and to look after the well being of all the men in camp. The warden also will visit the camp and keep in close touch with the work as it progresses.

Concrete Alley Finishing With Heavy Wooden Floats

Repeated floatings with heavy wooden floats is the essential feature of a concrete alley finishing method which has given good results at Milwaukee, Wis. This method is described by Mr. Charles J. Van Etta, Superintendent of Street Construction, in the May Concrete Highway Magazine.

As soon as the concrete has been brought to the proper contour, the surface is floated with a 2-in. oak plank float 14 in. by 16 in., with an 8-ft. ¾-in. gas pipe handle. The weight of this float removes all inequalities in the surface and compresses the concrete, as is shown by the quantity of water brought to the surface. A 1:1 dry mixture of cement and coarse, well graded sand is then sprinkled over the surface to absorb this excess water. About 1 sack of cement for 30 sq. yd. of surface is required. This dry mixture in acting as a blotter continues the removal of water from the slab by capillary attraction.



Finishing Concrete Alley Pavement With Heavy Wooden Floats.

After the dry mixture has been applied, it is thoroughly floated, or rather rubbed, until it has been completely incorporated with the body of the concrete. Subsequent floatings follow at short intervals until the mortar becomes pasty and adhesive and is slightly drawn along with the float. The entire finishing requires from four to seven floatings, depending on the original consistency of the concrete. Each floating compresses the concrete in proportion to the amount of water "pulled" to the surface.

This method of manipulation of the concrete is simply a substitution of the roller and belt method of finishing and is to be recommended only where obstacles are encountered which prevent the operation of the latter method.

Wisconsin System for Marking Highways

The road-signing system employed by the Wisconsin Highway Commission has been in service for two seasons and has proved very satisfactory. The following notes regarding it are taken from a discussion of J. T. Donaghey, maintenance engineer, at the last annual conference of the Association of State Highway Councils:

Our main truck line system is marked, beginning with 10, and going as high as necessary. We number from east to west and from the south to the north. The plan was originally designed for the benefit of our construction men. But now we are going to give the public some benefit of the mile numbers. Our mile-posts are flat, made of 3 by 6, and are painted with the number of the trunk highway. The first milepost has "1" on the south side and "2" on the north side of the post. The next one has "2" on the south side and "3" on the north. So you know you are in mile 2 or mile 3, as the case may be. Everything is on that basis.

This year we are getting out a new map and are preparing an index that will tell the traveler exactly where he is at any moment. Turning to trunk highway No. 17, it would have an index that would give the mileage of every town on that highway. So he can tell by the number of the milepost exactly how far it is to any point he wants to go.

We have adopted and are using a very cheap method of marking the system. We place them on the telephone poles at convenient places. We aim always to have a mark in sight on all trunk highways. At any point looking ahead you should be able to see a mark on a telephone post or posted on a culvert wall. The head walls of all culverts and bridges are painted white and the mark which we use is a triangle containing the trunk highway number. That mark is placed on the right head wall of the culvert. On the left is the number ofthe culvert.

We use wood entirely except for danger signs, which are enameled steel. The signs are set on cedar posts, which we can buy very cheap in Wisconsin.

The mile marks to be placed on the signs were determined by speedometer measurements. After the system was selected, as provided by the legislature, we made what we called a conditional survey of every mile on the system. We have in the office a chart from each county showing what was found at that time, the type and condition of the system. At the time we made those surveys we located the milepost and the speedometers were calibrated for correctness. We ran out a mile of steel tape and made our speedometers correspond with the actual measurements within a few feet. Many times we had to change the tires to get the speedometers to read correctly. We think it is very accurate as far as distance is concerned.

At the same time we located all signs. We had a black sign copy. A stake was set 2 ft. back of the point where the engineers determined the mileposts should be placed. It was placed where automobile lights could reach it at night, not too far toward the outer edge of the right of way, and still out of the way. The stake we placed carried the number of the trunk highway, and the number of the milepost. If it was a direction sign the stake carried the letter "D," the number of the sign, and the number of the trunk highway. The sign was painted from the information supplied on the sign copy, and the sign was erected by the county.

In marking through cities and villages we insisted upon having a mile mark on each side of all street intersections. That is, we have two mile marks as near as possible to the street intersections throughout the cities and villages. That is very essential. People get lost in the cities and villages easier than any other place. So we have adopted that plan of having two marks in every block. When you get near the intersection you know you are all right. The "R" or "L" shows you where to turn.

All trails passing through our state must be marked to correspond to our marking system. Persons interested in marking such trails must follow our marking instead of theirs So far, the marking of trails has done us more harm than good.

We mark detours plainly, with large white boards, showing the trunk highway number and an arrow pointing the direction of the detour at each end, and many times along the detour to show the traveler where to go. We also have paper detour signs which we nail on the telephone poles instead of painting on. In connection with that, we have the patrolman maintain the detour on his regular sections.

Cost of Plowing and Grading With Tractors

Interesting data on tractor operations in British Columbia were given by Mr. Arthur Dixon, District Engineer, in a paper presented recently at a meeting of the Provincial District Engineers of British Columbia. His figures relate to work done by a Wallis machine. This tractor has a drawbar pull of 14 HP., is of the round wheel type, with a single wheel in front for steering, and weighs approximately 3,500 lb. The following is abstracted from Mr. Dixon's paper:

The work carried out last year with the tractor has principally consisted of plowing, grading and in a few cases, of hauling material. In plowing the tractor was equipped with a large 4-horse breaking plow, and averaged at the rate of 24 round trips of ½ mile per day of 8 hours, or 12 miles, which is approximately equal to two acres. The operating expenses were:

Rental and depreciation of tractor	$ 5.00
Gasoline 8 gal., at 45 ct.	3.60
Engineer's wages	5.00
1 man at $4.25 and 1 man at $4.00	8.25
Oil, grease and waste	1.00
Total	$22.85

or $11.42 per acre.

Four horses could not begin to do this amount of plowing in a day; indeed, an acre in a similar class of material would be considered a very big 8-hour day's work. Even putting it at this the cost would be:

4 horses at $2.25	$ 9.00
1 driver	4.25
1 ploughman	4.00
1 extra man	4.00
Total	$21.25

or $21.25 per acre.

There were instances where plowing was found to cost more with the tractor, than that stated above, due to changed conditions in material, heavier roots to be taken out, etc., but this would not alter the proportionate cost.

In heavy grading, no correct details are available, but the tractor will accomplish two to three times more work than a 6-horse team and grader. One case: A short piece of grading in hard silt about ¼ of a mile long was completed without plowing in six hours with the tractor. With teams it would have been necessary to use the plow and have taken a good day's work to finish.

The costs were as follows:

BY TRACTOR.	
Rental and depreciation of tractor, 6 hours	$ 3.75
Gasoline	2.70
Driver's wages	3.75
Grader man	3.87
Extra mah	3.00
Total	$17.07

BY TEAM OF SIX HORSES.	
6 horses at $2.25	$13.50
1 driver	4.25
1 grader man	4.25
1 extra man	4.00
	$26.00

The tractor will easily travel with heavy grader, camp outfit, and supplies on wagon, and water tank, making 30 miles per day, or the same work as three good teams, with a saving over the team work of $10. The same applies to hauling hay, grain, lumber, etc. The tractor is capable of doing about three times as much as a team, and show a saving, thereby proving the following statement: A horse is capable of continuous pull of one-tenth its own weight; a tractor of this size has a draw bar pull at 2½ miles per hour of 1,300 lb. or approximately one-third of its weight. It is this greater pulling capacity, together with its ability to keep it up for 24 hours per day if necessary, that makes the tractor produce power at a lower cost than horses.

State Highway Work in Washington.—The State Highway Department of Washington has located, prepared plans and estimates, secured right of way and let 113 contracts for the construction and improvement of 525.36 miles of new road at a total cost, not including engineering, of $10,378,000, and for the construction of of 25 concrete and steel bridges at a total cost, exclusive of engineering, of $1,001,000.

New Highway Investigations of the Bureau of Public Roads*

By A. T. GOLDBECK,
Testing Engineer, Bureau of Public Roads, U. S. Department of Agriculture.

There have been three more or less distinct eras of road construction in this country, marked by the character of traffic the roads have had to carry. Statistics show that in 1899 there were but 3,700 passengers and commercial motor vehicles produced in this country, and up to that time the roads were subjected almost entirely to horse-drawn vehicles. In general, the loads hauled were comparatively light; the traffic was rather slow moving, and the principal destructive effect of this traffic was that of abrasion of the road surface. For carrying such traffic water-bound macadam and gravel roads were highly satisfactory.

After 1899, however, motor vehicles began to increase in great numbers, with an enormous advance in 1909, when 127,731 motor vehicles were manufactured. In general, these vehicles were comparatively light, were rubber-tired and moved at relatively high speeds, and in consequence an entirely new type of destructive effect was created on the roads. The road surface no longer disintegrfated through actual abrasion, but the high speed of the vehicles very effectively removed the fine binding material from the surface, the individual pieces of stone became loosened and the road ravelled. It then became necessary to adopt new types of construction in which the road surface was more securely bonded together.

Very recently, within the past five years, we have seen still a third type of road failure, due to the large increase of comparatively slow moving but very heavy motor trucks. We have seen roads that were considered excellent types for fast moving light motor vehicles pounded to pieces through the action of heavy motor truck traffic, and this kind of traffic is the traffic we must design our roads to withstand in the future. The heavy motor truck came upon us very suddenly and its effect on the roads was brought very forcibly to our attention through the combined action of the exceedingly heavy motor truck hauling during the war and the soft, thawing subgrades following an unusually severe winter. We found that our road surfaces, under the conditions of subgrade as they existed then, and as they are likely to exist in the future, were totally inadequate to support such heavy load concentrations.

In view of these conditions, and in view of the enormous road building program with which we are faced, it has become necessary to gain every possible bit of information on the load supporting properties of different types of road surfaces as quickly as possible. The existing car and labor shortage will force use to build the best we know how with materials available, and this will mean the construction of many different types of roads. Different subgrades, having variable load supporting properties with the drainage methods now used, will require different types of road surfaces to withstand the traffic. Economic conditions will render it advisable to build one type of road in a certain locality rather than another type, but we should know definitely how to design these different types so that they will be comparable in their load carrying capacity.

Given a definite set of conditions, such as character of subgrade, weather conditions, and maximum allowable load on a road, we should be able to say with certainty how to design that road for the given conditions so that it will not fail under the traffic, but at the same time will be built with the greatest economy. The bridge builder, having a given set of conditions in mind, knowing the maximum loads to which his bridge will be subjected is able to design his bridge in a rational manner so that when it is constructed according to his plans and specifications he knows his bridge has ample safety. Would this not be a desirable status for the science of road building, and would it not be desirable for us to get away from the old empirical methods and put the design of roads on at least as high a basis as that of the design of bridge structures? Such a basis is not beyond the realms of possibility and will probably be accomplished not many years in the future.

With some of the foregoing problems in mind, we have been performing a number of investigations which may be subdivided as follows:

1. A study of the amount of impact delivered by motor trucks to roads.
2. A study of the effect of this impact on different types of road surfaces.
3. A study of the effect of traffic on different types of road surfaces.
4. A study of the bearing value of subgrades as affected by moisture.

Impact Delivered by Motor Trucks to Roads.—Almost anyone would be willing to grant that our road surfaces capable of carrying ordinary passenger automobiles would not be likely to fail under the mere static weight of our heavily loaded motor trucks, and an investigation tending to confirm this idea was made on the Camp Humphreys concrete road, in which it was shown quite conclusively that static loads produce very low stress in an 8-in. concrete slab—so low in fact that it was quite evident that the mere weight of the truck at rest on the road surface, is in general not enough to produce failure of that surface. Heavy trucks do not merely rest on the surface, however, but move with more or less speed, and the surfacing being not perfectly smooth produces vertical motion in the truck so that the wheels exert more or less of an impact action on the surface.

With the idea of determining just how much this impact force actually is, we started a series of investigations in order to measure it. For these tests we constructed a concrete lined pit in the road surface and in this pit we placed a hydraulic jack, to the plunger of which was fastened an enlarged head and the top of which protruded slightly above the surface of the pavement. A number of ½ by ½ in. copper cylinders were carefully prepared and were given a special heat treatment in order to anneal them and render them very uniform in quality. To determine the amount of impact exerted by a truck, one of these copper cylinders is placed under the plunger of the jack and the rear wheel of the truck is caused to strike this plunger by falling through a known height when the truck is moving at a known speed. The blow delivered by the wheel in falling on the plunger is transmitted to the copper cylinder, shortening it to a measured amount.

In these investigations a large number of tests were made in which the height of fall was varied from ¼ in. up to 3 in., a new copper cylinder being used for each test and each copper cylinder being deformed a different amount, depending upon the force of the blow delivered to it. To measure the blow, copper cylinders, selected at random from the same lot, were compressed in a testing machine, and the loads required to compress them known amounts were obtained. The compression of the copper cylinders under impact was then compared with the compression obtained from known loads applied by the testing machine, and in this way it was possible to determine the force of the blow delivered by the truck in terms of an equivalent static load.

Many things have been discovered with regard to the amount of force delivered to the road surface by traffic. Thus, we now know that under certain extreme conditions the force of the blow may be five or six times as much as that exerted by the truck when it is at rest on the road surface. This condition was obtained, for instance, when an army truck, the upsprung weight of one rear wheel of which was 1,837 lb., and the total weight on one rear wheel was 7,750 lb., fell through a height of 3 in. while traveling at a speed of 15 miles per hour. The force of the blow produced by this wheel was approximately 42,000 lb., or over five times the force produced by that same wheel at rest on the road. This is an extreme case, and under actual conditions would require an exceedingly rough road for such a blow to be delivered.

It may be interesting to note that the so-called unsprung weight of a truck—that is, the weight not supported on the springs—has great influence on the force delivered to the road surface, and a heavy unsprung weight in general produces a heavy blow to the road. A large number of results have been obtained from these investigations, giving us information on the force likely to be exerted on road surfaces by different weights of vehicles; and these tests are being conducted in order to determine the effect of pneumatic tires as compared with solid tires and of special types of tires and wheels designed to provide extra cushioning effect over that of solid tires.

The tests are conducted to give conditions of impact approximating those actually obtained in the road, thus:

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*Paper presented at last annual convention of the American Road Builders' Association.

(1) The truck wheel is caused to fall on the weighing device;

(2) The wheel mounts an obstruction placed on the weighing device;

(3) The wheel falls from different heights on a wedge-shaped block placed on the weighing device.

This latter condition would, for instance, aproximate that in which a wheel jumps over a hole in the road and lands on the far side, and this is one of the most severe conditions of impact.

A number of detailed investigations were made in order to obtain information in connection with the main investigation. Thus photographs were taken showing the path described by the body and that described by the hub of the truck. In addition, measurements were taken of the deflection of the rear spring at different periods before and after the impact. In this way we are enabled to separate the effect of the unsprung portion from that of the sprung portion of the truck, and we have thus been able to find that the unsprung portion is of great importance in determining the amount of impact delivered to the road. When these investigations are completed we should have rather full information on one very essential step in the design of roads, namely, the force delivered to the road surface.

It is expected that within the coming years the tests already conducted will be supplemented by additional tests, using motor trucks fitted with a special device which will measure the actual force of impact delivered to roads of various kinds. This device depends in principle on the autographic measurement of the path described by the truck wheels in traveling over the road surface. When an accurate record of the path of the wheel is known, it is a simple problem in physics to calculate the force delivered to the road.

Effect of Impact on Different Types of Road Surfaces.—A knowledge of the force delivered to a road surface by traffic of itself is not of very great value unless we can couple this information with the effect of that force on different types of surfaces. We are, therefore, conducting a second series of tests with this idea in view, namely, determining the effect of impact on different kinds of road surfaces. For carrying on this investigation we have constructed a number of slabs 7 ft. square and laid directly on the subgrade. These specimens include concrete slab of 1:1½:3 mix, 2, 4, 6, 8 and 10 in. in thickness, and several slabs 14 ft. square, 6 in. in thickness. We have a number of different types of brick slabs built with wire-cut lug, repressed and also vertical fiber brick. Some of these are laid with sand-cushion construction, some with monolithic and some with semi-monolithic construction. We have used sand cushion and also bituminous mastic cushion. We have likewise used several different types of filler, including cement grout, bituminous filler and bituminous mastic filler. The concrete base is 4 in. under some of the slabs and 6 in. under some of the others. We have likewise constructed slabs with 3-in. wire-cut lug brick, monolithic construction with 3 and 4-in. concrete bases. We have also constructed a few slabs laid on 6 in. and 12 in. of macadam. We aim to continue these tests, using a large number of different types of construction that may look promising.

The above slabs will be subjected to impact by means of a special machine constructed for that purpose. It is designed to give impact conditions similar to those given by the rear wheel of a heavy truck. In its present form the machine consists of a 2,000-lb. weight shod at the bottom with a 12-in. solid rubber tire and carrying a 6,000-lb. weight supported through the use of a single heavy truck spring. The entire weight of 8,000 lb. may be raised by means of a cam, gear-driven by a gasoline engine, so that repeated impacts may be delivered at one spot on the slab until failure takes place. We have instruments mounted on the machine which autographicaly show us the deceleration or suddenness with which the weight is brought to rest upon the slab. From these curves it is possible for us to measure the exact force of the impact. We likewise have instruments to enable us to measure very carefully the deformation of the slab under the repeated blows of this machine.

As the condition of the subgrade will undoubtedly affect the load supporting value of the surfacing, we have constructed duplicate sets of specimens, one set of which is laid on a subgrade which will be purposely kept in a moist condition and, therefore, be of low bearing value, and the other is laid on a subgrade which we will endeavor to keep dry and thus obtain a high bearing value. From the results of these tests we should be able to say just what types of roads may be considered as comparable so far as their resistance to pounding of heavy trucks is concerned.

Effect of Traffic on Different Types of Road Surfaces.—We are conducting still a third series of tests which were designed primarily to enable us to develop suitable laboratory tests for stone paving block, but which we are using incidentally to give us some idea of the relative wearing qualities of different types of surfacings when they are all subjected to exactly the same traffic.

We have constructed a straight track, 400 ft. in length and 2 ft. in width, in which are laid 49 different sections of pavements. As at present constructed, these sections include concrete having different kinds of coarse aggregates including trap rock, gneiss, gravel, soft sandstone, limestone and air-cooled blast furnace slag. There a number of different kinds of brick pavements in which brick having different percentages of wear are used, the percentages being 16, 19 and 24 per cent in the rattler test. There are likewise sections in which 3-in. brick are used. Both sand cushion and semi-monolithic construction have been employed. The type of filler has also been varied to include cement grout and bituminous fillers. There are also a number of stone block sections constructed of blocks from different parts of the country. The filler has likewise been made to include bituminous as well as portland cement fillers.

Over these sections a wear machine is hauled by means of a cable-way. This machine consists essentially of five large cast iron wheels, each weighing 1,000 lb., with a tire width of 2 in. Each of these wheels is perfectly free and independent of the remaining wheels and its full weight is exerted on the road surface. They are so arranged that they travel over a strip 12 in. in width and there is considerable impact action exerted by the heavy unsprung weight of these wheels, and the action of this device is rather one of heavy impact than abrasion.

Bearing Power of Subgrades as Affected by Moisture.—It is common knowledge that whereas city pavements may stand exceedingly heavy traffic, those same pavements when laid on country highways develop weak spots and defects which require considerable maintenance. The difference between the city pavement and the country highway very obviously is that of drainage. The subgrade under city streets is generally in very much better condition than that of country highways because it is possible to keep the subgrade under city streets very much drier than the subgrades under country highways.

The bearing value of most soils is very greatly decreased by the presence of water, and one of our greatest problems in road construction today is to develop means for keeping water out of the subgrade. It would seem that our present-day methods of drainage of roads do not always accomplish the purposes for which they were designed, and tests are being undertaken to discover means for enabling us to develop the bearing value of subgrades to the maximum possible extent. The experiments in this direction include experiments to determine the bearing value of soils containing different percentages of moisture studies of capillarity in soils, and will include studies by means of models and full sized road sections to determine the best means for excluding water from the subgrade.

We are making an earnest effort to place the building on a much more scientific basis than exists at the present time. We should like to be able to gain enough knowledge so that having a given set of conditions of climate, subgrade and traffic, we shall be able to say with considerable certainty what constitute the best type of road for those conditions. It would be very desirable if we were able to obtain information enabling us to say definitely that one type of road was comparable with another for carrying the same traffic. We believe that knowledge of this kind can only be had through tests of the character described, in conjunction with a study of the behavior of roads under service conditions.

Labor required for Care of Working Horses—According to the U. S. Department of Agriculture, it requires 170 hours of labor per year to take proper care of a working horse. At this rate one man working 8 hours daily, 300 days a year, would care for 14 horses per day.

Reducing Hazards in Highway Contracts*

By HERBERT NUNN,

Chief Engineer, Oregon State Highway Commission.

The State Highway Commission of Oregon has tried to make it as easy as possible in a legitimate way, for the contractor to give an intelligent bid; to eliminate the hazard from bids on highways. Every hazard which we eliminate will react in lower bids. For this reason the Highway Commission of Oregon is guaranteeing the freight rate. It is purchasing cement and asphalt and asphalt and guaranteeing the price. It is now paying for material in stock piles. We are giving estimates of completed work regardless of the size of the contract, so as to cut down the retained percentage. And, in fact, we are trying to do everything that is fair and honest for the contractor.

In the way of specifications the engineer is often criticised, but there is one thing this group of contractors should remember: That the engineer does not make state laws. You should also remember that our contracts are state contracts and that they must comply with the federal standards. Therefore it is practically impossible to change the present standard form of our contracts, although we are doing it at this moment to some extent.

It has been suggested by an eastern engineer that no charge should be made for plans. I think that is true. As a matter of fact, there is no charge in the Oregon State Highway Department for plans. If the plans are returned the money is refunded.

It has also been recommended by engineers that guarantees should be abolished. That is something in this state over which the engineer has no control.

It has been recommended that certified checks be reduced to 2 per cent. I think that is fair and should be done; but under our state law it cannot be done.

A great many of these questions are questions for future legislation. Although the engineer may agree that the contractor is right, they are not questions in which he can help.

The engineer is particularly interested at this time in cooperation by the contractors, because he is interested in his engineering expense. In order for an engineer to get by with a reasonable amount and within the legal limit, which is 10 per cent in this state, he must have active and good co-operation with the contractor. This means that this state should have competent contractors, men who are well financed, men who know how to handle work, and men who are not of the bankrupt order. There is nothing that the engineer hates so badly as to have to go out and take charge of a contract with an engineering organization. An engineering organization is not built up along the lines that a contractor's organization should be. Therefore it is impossible for us to handle work as economically and to take the personal interest in it that a contractor would. In order to take an interest in work a man must be financially interested.

The time limit on a contract is set by the engineer to give him a reasonable time in which to complete a contract and to eliminate the incompetent contractor who will come in and expect to drag their work over a period of two or three years while he learns the business. When you exceed your time limit, we will say if it is a six months' time limit, suppose you exceed it a year, it will increase the engineering cost at least 50 per cent, and this places the engineer in a very embrassing position, not only as to the legal cost of his engineering, but with the Highway Commission. I hope that contractors will bear that in mind.

The engineer of today believes that a contractor is entitled to a clear specification, so that he can submit an intelligent bid; and we believe that he is entitled to a sure and a fair profit. We believe every hazard should be eliminated that it is possible to eliminate.

There are one or two things more in the specifications which I might discuss, and one is a question of the arbitration clause. I am going to be frank. I am opposed to the arbitration clause. Whenever an engineer permits an arbitration clause to be attached to his specification, he admits that he is either incompetent or unfair. The arbitration clause would permit incompetent contractors to dispute every final estimate. No engineer who permits that clause will ever be able to control his final estimate. Furthermore, I am sure that the government would never accept such a clause. I am very much opposed to this, and the contractor who attempts to insert the arbitration clause is going to find a reaction in the public. So many contracts will be disputed that the public will become suspicious, and the whole thing will finally wind up exactly where you don't want it to end, in force account being substituted for the present methods of contract work.

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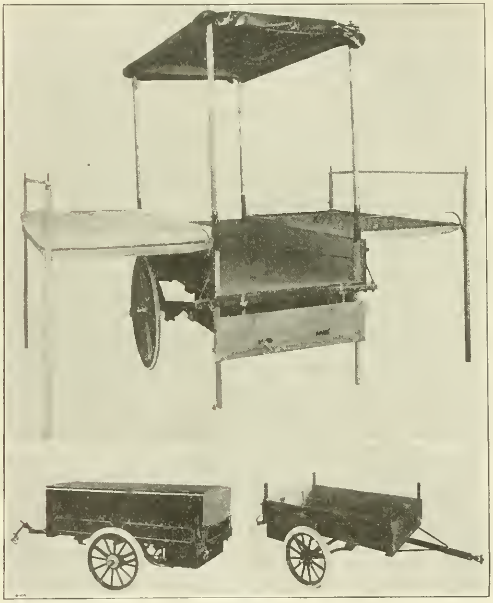
*Abstract of an address presented March 3 before the first annual convention of the Associated General Contractors of the Pacific Northwest.

Folding Camp Trailer for Road Maintenance Work

In our May 5 issue we described briefly the trailer camp arrangement of the Maintenance and Repair Bureau of the Ohio State Highway Department. A view of the camp trailer ready for the night was shown with the article. Mr. D. O. Stene, maintenance engineer of the Bureau, has furnished the following additional information regarding this convenient outfit:



Special Express Body, Trailer Packed, for the Next Move, and Outfit Partly Assembled.

The Bureau owns six complete bituminous surface treating outfits and operates them by force account. Each of these machines is routed over several counties a season so that their stay in a given locality is limited to a week or 10 days. The superintendent in charge of the gang is the only man whose board and room expenses are paid by the department. Five or six other experienced men are carried along to operate the equipment and a compact, two-wheeled, folding camp trailer is provided to furnish sleeping quarters for these men.

This trailer consists of a special express body mounted on two standard board wheels equipped with pneumatic tires. On each side of the body is hinged a double cot bed spring which can be folded in for traveling and folded out and supported along the outer edge to form a comfortable bed for two men when ready to pitch camp. When the size of the gang is more than four men the regular beds are high enough to allow a folding cot to be placed under each one providing sleeping accommodations for a total of six men. The whole outfit is covered by a special wall tent supported by poles from each corner of the trailer and the braces holding the outer edges of the folding beds. The cover to the trailer body, which protects the equipment while in transit, raises up and forms the top of the tent while camping.

A large zinc lined drawer under the bed of the trailer is designed to be used as a refrigerator and storage space for food. While moving between jobs the camp trailer is attached to the superintendent's touring car.

A separate 10-ft. by 12-ft. standard wall tent and camp stove are also supplied which makes a very complete and comfortable camp for the men.

The department began using camp trailers so the men would always be near the equipment and work being done, but as living expenses have rapidly advanced and it is becoming increasingly difficult to secure room and board at farm houses, they have more than ever proven their worth. As all the work done by the surface treating outfits is outside of municipalities and is limited to the summer months, these camping outfits have also been popular with the men.

How to Secure Co-Operation Between Engineers and Contractors*

By CHAS. M. UPHAM,

Chief Engineer, Delaware State Highway Department.

I think many of the misunderstandings that have grown out of the relations between contractors and engineers are due to abuse both on the contractors' side and on the engineers' side. I do not think that either one is at fault, but I think that both are at fault. And, assuming this condition, what we want to do is to remedy it as soon as possible. I am going to read the six points as I have analyzed them, and then we will amplify them slightly.

The requirements on the part of the engineer are: First, there shall be substantial administration and common sense engineering; second, the engineer must require things within reason and draw his specifications in a clear, definite manner; third, the engineer should furnish competent and experienced inspection. Now those are the only three points on the part of the engineer, and a person can discuss this, and it will come right back to those three points—common sense and substantial engineering; reasonable and definite specifications; competent and experienced inspection. Now, as contractors, can you think of any further requirement that will bring about a complete co-operation or satisfactory relations between the engineers and contractors?

On the part of the contractors, there are three points which seem to be absolutely necessary, and the first of those points is sufficient and satisfactory equipment—we all concede that this is necessary. The second point is adequate funds—I think a good many differences between contractors and engineers have arisen from the fact that the contractor has not had the liquid finances to turn out the job. And the third point is competent and efficient personnel of organization. Now I think you can also discuss the points from a contractor's point of view, and you will come right back to one of those three points.

One reason why there has been a little better co-operation recently between engineers and contractors is because many of the present day contractors were former engineers, and they have seen the game from both sides. That does not mean that they are any better qualified as contractors, but simply that they know the requirements of the engineers, or they have been trained from that side so they can anticipate any conditions.

A few years ago I understand that Delaware and Upham were boycotted as far as contractors went, and that we could not get any contractors to bid in Delaware. I heard that from several sources, both from contractors and engineers. The reason for it was that we were too strict. Now I will tell you what that strictness consisted of: We cut out everything in the specifications that we did not require a contractor to do, but we left in the things we did want done, and then we required the contractor to do them. When the contractor was making up his bid, time and again every one of our engineers was instructed to have the contractor read and re-read the specifications and see what he could do the work for and then bid on what he could do the work for. That was the reason that Delaware was once boycotted. It was soon found out, though, by contractors that we were treating every contractor the same; that all a contractor had to do was to read what was in the specifications, figure what he could do the work for and then come down there and bid. Many contractors did that. They came and, with but a single exception, every contractor that has, up to date, finished work in Delaware, has come back and bid on more work, and today we have some contractors waiting for us to bring out work. Now I base that on the very fact that our specifications are definite, our inspectors are just as good as we can obtain, and we try to have reasonable and fair engineering.

In the conferences at which we draw our specifications we appoint either one or two men to represent the contractor's side in all discussions. I think that is a point well taken. In other words, when a discussion takes place, they are not all on the side of the engineers; there are two that are on the side of the contractors and discuss the point from that side. One of them has been in the contracting business and was superintendent for a contractor; the other was an engineer.

In one particular instance, I know of a contractor bidding on two pieces of work that were identical. The conditions, as nearly as we could determine, were identical, but still the contractor bid $15,000 more on one job than he did on the other. When asked why he did it he said it was because he had had such and such a man as an engineer on that particular contract.

One other point in regard to definite specifications is that, so far as possible, detailed procedures should be mentioned. And one other very important point is the method of payment, as to whether or not excavation should be paid for in relaying pipe, or whether the labor, the pipe excavation and everything should be considered in the unit cost.

Now, to come to the third point on the engineering side, the inspectors. Many people have got high priced, experienced engineers and they have made every possible effort to have good specifications, but when it came to the inspector, who is absolutely the most important man on the entire job, they would have some inexperienced man or some man just out of college. I think it is beginning to be realized that the inspector should be one of the very best men in the entire organization, and as soon as that is realized a great step forward in the relation of the contractor and the engineer will have been taken.

An inspector must absolutely know the difference between the essentials and non-essentials on a contract—if there may be termed essentials and non-essentials. But the one point that he must watch is to keep the contract going, if possible. I recall going on a job at one time when an inspector, because of a clause in the specification, insisted on requiring the contractor to pass all his cement through a 200-mesh sieve. I imagine that would hold up the progress slightly when they were using a carload a day.

Contractors and engineers both want to get a good job, if they don't want anything else. Even a dishonest engineer wants to get a good job. I think it has been truly said that the first ideal of a contractor is to get a perfect job, but the most important feature, from a contractor's point of view, is to make money. Now I think those are perfectly legitimate; his first idea is to get a good job, and the most important point is to make money. But I think the first ideal of contractors is to get a good job.

Now I think we could ramble on for a long time, but each one of these points will come right back to those six points—the six points of co-operation, I will call them. The first is, substantial administration and good engineering; second, reasonable and definite specifications; third, competent and experienced inspection. From the contractor's side: First, sufficient and satisfactory equipment; second, adequate funds; third, competent and efficient personnel. I think you will agree with me that if those points are carried out, both by contractors and the engineers, it will be difficult to have anything but close co-operation.

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*From a paper presented at the last annual convention of the American Road Builders' Association.

Wants Engineer Member for International Joint Commission.—The Executive Committee of the American Association of Engineers has asked its chapters situated in states bordering on the Great Lakes and the Canadian border to urge upon the President of the United States and the United States Senators representing their respective States the desirability of appointing an engineer to the vacancy on the International Joint Commission, in recognition of the large engineering problems involved in the work of the commission.

Cost of Loading Gravel by Mechanical Loaders and by Hand

Comparative figures on the cost of loading road gravel by various methods were given by Mr. P. Philips, District Engineer of the Department of Public Works of British Columbia, in a paper presented at the recent convention of the Provincial District Engineers. The matter following is taken from his paper:

A "Haiss" mechanical loader was introduced to Delta district this past summer and has been in continuous operation up to the present time. This machine has given results which have more than justified its introduction. With a few exceptions the pits in Delta district are not ideally situated for loading gravel, having shallow faces. The machine has reduced the cost of loading gravel by at least 50 per cent, for it will easily load 160 cu. yd. per day at a cost of 12.3 ct. per cubic yard and under more favorable conditions has loaded for 6.6 ct. per cubic yard.

Where the gravel is to be hauled a long distance it is absolutely essential that the loader be kept in constant operation either by having portable bunkers in conjunction with it or by increasing the number of trucks.

The loader is self-propelling, simple to operate, requires only an intelligent skilled laborer to run it. The crew consists of three men, one to operate the machine (this man is paid 50 ct. per hour more than the ordinary laborer), two men stripping the face of pit, loosening the gravel, cleaning away roots and debris. With the above crew the loader can be fed to its full capacity. If the pit has a high face one man can be dispensed with.

A clamshell was used on Nicomen slough for loading rock tailings into scows. The cost of loading 2,000 cu. yd. of material was 6 ct. per cubic yard; 2,000 cu. yd. cost 16 ct. per yard to load on account of an insufficiency of scows.

The capacity of bucket is ⅞ cu. yd. and the daily capacity is 300 cu. yd. The daily cost of operation is:

Engineer, fireman and helper	$15.00
Fuel, oil, upkeep, depreciation	5.50
	$20.50
Cost per cubic yard	6.8 ct.

Where the material is suitable for scraper work this method compares favorably with the mechanical loader. The cost of loading 90 cu. yd. of fine rock with team and scraper was 14 ct. per cubic yard. It must be considered whether the amount of material available will justify the expense of erecting bunkers.

A man will shovel loose gravel at the rate of 15 cu. yd. per day. The cost is 27 ct. per cubic yard.

The following tabulation shows costs for loading truck, assuming the truck makes 8 trips per day with a load of 2 cu. yd., taking into consideration the cost due to delay in loading:

LOADING BY HAND—16 CU. YD.

3 men for 2.8 hours	$ 4.20
2.8 hours delay of auto truck at $30 per day	10.50
Total cost	$14.70

MECHANICAL LOADER—16 CU. YD.

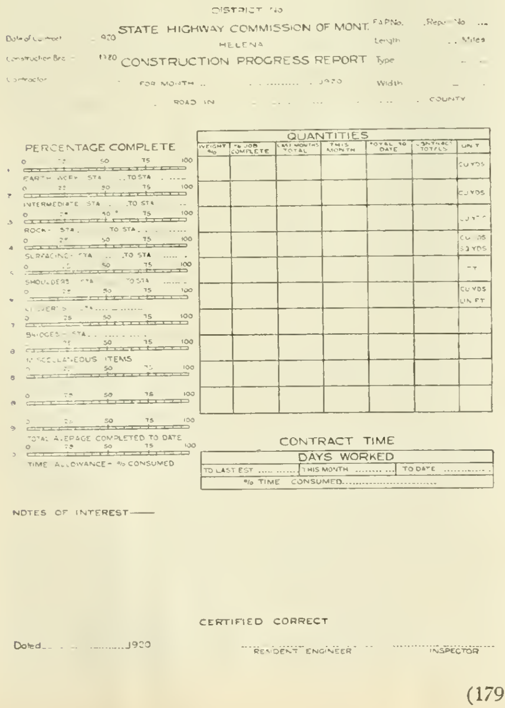
16 cu. yd. at 12.3 ct.	$ 1.97
4 5 hours delay of truck	3.00
Total cost	$ 4.97

Montana Rental Rates for Trucks and Tractors.—Under the revised policy adopted May 3 by the State Highway Commission of Montana, contractors are required to make a deposit for surplus war department equipment rented or leased to them, as a guarantee of the safe return of the unit in proper condition. A deposit of $1,000 is required for each truck; $1,500 per each 120-HP. caterpillar; and 20 per cent of the value for miscellaneous equipment. Rental rates to contractors are as follows:

For each truck $200 per month during the period May 1 to Nov. 1, except that equipment used by the contractor during other calendar months will be paid for at the above rate; 120-HP. caterpillar, $300 per month with the same condition as above. The other equipment available for the use of contractors will be on a monthly rental basis as above, the rental to be calculated by the Chief Engineer on the basis of annual depreciation.

No contractor may secure surplus war equipment until a contract has been awarded him; and surplus war equipment may be used by contractors only on state work.

Forms of Montana State Highway Commission for Construction Progress Reports



DISTRICT No

Date of Contract ...... 1920 STATE HIGHWAY COMMISSION OF MONT. FAP No. ...... Report No ......

HELENA Length ...... Miles

Construction Begun ...... 1920 CONSTRUCTION PROGRESS REPORT Type ......

Contractor ...... FOR MONTH ...... 1920 Width ......

...... ROAD IN ...... COUNTY

PERCENTAGE COMPLETE

0 25 50 75 100
1 EARTH WORK STA ...... TO STA ......
0 25 50 75 100
2 INTERMEDIATE STA ...... TO STA ......
0 25 50 75 100
3 ROCK STA ...... TO STA ......
0 25 50 75 100
4 SURFACING STA ...... TO STA ......
0 25 50 75 100
5 SHOULDERS STA ...... TO STA ......
0 25 50 75 100
6 CULVERTS STA ......
0 25 50 75 100
7 BRIDGES STA ......
0 25 50 75 100
8 MISCELLANEOUS ITEMS
0 25 50 75 100
8
0 25 50 75 100
8
0 25 50 75 100
9 TOTAL AVERAGE COMPLETED TO DATE
0 25 50 75 100
0 TIME ALLOWANCE—% CONSUMED

QUANTITIES

WEIGHT %	% JOB COMPLETE	LAST MONTHS TOTAL	THIS MONTH	TOTAL TO DATE	CONTRACT TOTALS	UNIT
						CU YDS
						CU YDS
						CU YDS
						CU YDS SQ YDS
						FT
						CU YDS LIN FT

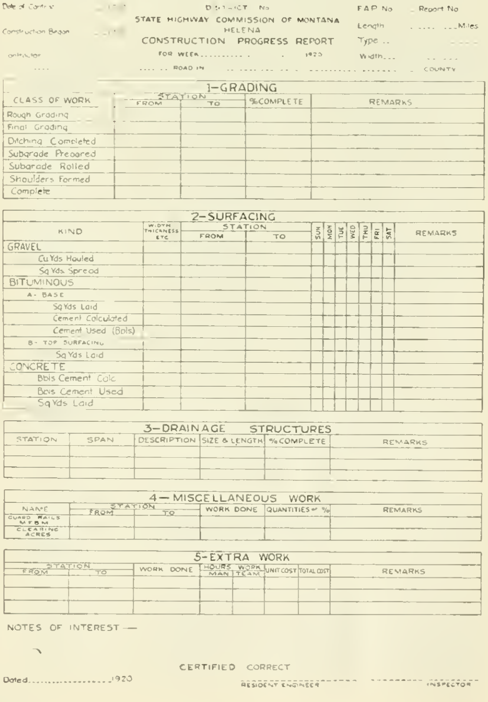
CONTRACT TIME

DAYS WORKED		
TO LAST EST	THIS MONTH	TO DATE ......
% TIME CONSUMED		

NOTES OF INTEREST——

CERTIFIED CORRECT

Dated ...... 1920 ...... RESIDENT ENGINEER ...... INSPECTOR



Date of Contract ...... 1920 DISTRICT No FAP No ...... Report No

STATE HIGHWAY COMMISSION OF MONTANA

Construction Begun ...... 1920 HELENA Length ...... Miles

CONSTRUCTION PROGRESS REPORT Type ......

Contractor FOR WEEK ...... 1920 Width ......

...... ROAD IN ...... COUNTY

1—GRADING

CLASS OF WORK	STATION FROM	STATION TO	% COMPLETE	REMARKS
Rough Grading				
Final Grading				
Ditching Completed				
Subgrade Prepared				
Subgrade Rolled				
Shoulders Formed				
Complete				

2—SURFACING

KIND	WIDTH THICKNESS ETC	STATION FROM	STATION TO	SUN	MON	TUE	WED	THU	FRI	SAT	REMARKS
GRAVEL											
Cu Yds Hauled											
Sq Yds Spread											
BITUMINOUS											
A- BASE											
Sq Yds Laid											
Cement Calculated											
Cement Used (Bbls)											
B- TOP SURFACING											
Sq Yds Laid											
CONCRETE											
Bbls Cement Calc											
Bbls Cement Used											
Sq Yds Laid											

3—DRAINAGE STRUCTURES

STATION	SPAN	DESCRIPTION	SIZE & LENGTH	% COMPLETE	REMARKS

4—MISCELLANEOUS WORK

NAME	STATION FROM	STATION TO	WORK DONE	QUANTITIES or %	REMARKS
GUARD RAILS MFBM					
CLEARING ACRES					

5—EXTRA WORK

STATION FROM	STATION TO	WORK DONE	HOURS WORK MAN	HOURS WORK TEAM	UNIT COST	TOTAL COST	REMARKS

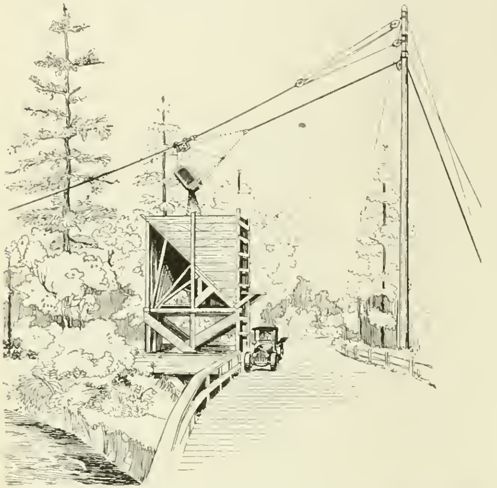
NOTES OF INTEREST —

CERTIFIED CORRECT

Dated ...... 1920 ...... RESIDENT ENGINEER ...... INSPECTOR

County Owned Plants for Development of Local Supplies of Road Materials

An excellent example of intensive development of local sources of road-building material is offered by Grays Harbor County, Washington. A few years ago it was difficult to get contractors to bid on road and bridge work in that county because the lack of nearby commercial gravel plants made materials high as to cost and uncertain as to delivery. Now the county controls a number of tracts of gravel in various parts of the county and owns and operates four Sauerman dragline cableway excavators, producing ample sand and gravel for all county road and bridge work; likewise guaranteeing contractors a fixed price on gravel that has already passed the engineers' specifications.



Outfit Set Up for Temporary Operations in Utilizing Deposits Adjacent to Gravel Road Job.

Three of the dragline cableway excavators are installed in permanent pits with the necessary screening equipment for turning out material properly graded for whatever work is at hand.

The fourth outfit has been used for temporary operations in utilizing deposits adjacent to gravel road jobs. The accompanying sketch shows a set-up of this 500-ft. span cableway with ¾ cu. yd. bucket on a road job near Humptulips, Wash., where screened material was not required.

The dragline spans a small stream and lifts the gravel from a bar in the river to the loading bin at the side of the road. Operated by an 8¼ by 10 (40 hp.) double drum steam hoisting engine, this machine handles about 200 cu. yd. of gravel per day when the necessary motor trucks are available to take the material away as fast as the excavator fills up the bin. One man controls the entire operation of the cableway. Moving the outfit to a new location and re-erecting requires the labor of 6 men for about 10 days.

Snow Melting Machine Used in Finnish Cities.—A snow melting machine, which is stated to have effected a 60 per cent reduction in the cost of snow removal from streets, is used by the city of Helsingfors, Finland. The machine is described as follows in a recent daily U. S. Commerce Report:

> The melting capacity of the machine is 26 or more cubic yards per hour, depending upon the size of the machine and the kind of fuel used. Cheap fuel, such as wood coke, coal, kerosene and crude oil may be used. The smallest apparatus, weighing 500 lb. and requiring four men to keep it supplied with snow and fuel, uses, when fired with coke, 200 lb. of fuel and melts 32 cu. yd. of snow per hour. The machine utilizes 90 per cent of the heat developed. The apparatus consists of an iron furnace, water-jacketed all around; a snow receiver, or hopper, surrounding the upper part of the furnace; a system of ducts by means of which the water from the melting snow is again forced into the snow, thus increasing the melting a high-pressure fan driven by a small electric motor for creating a strong artificial draft and driving the heat developed out through the snow. The cooling of the furnace walls is accomplished by leading the snow water through the water jacket from which it is forced out again through jets into the snow. The apparatus melts snow and ice. The dirt and gravel in the snow is automatically separated from the water outside the machine to avoid clogging drains or gutters. The machine is used in Finland by street-cleaning departments, banks, public buildings, large business houses and property owners.

The machine is the invention of a Finnish engineer and is manufactured by Rydman & Savonius, Helsingfors. It is now used in Finland, Scandinavia, and Russia, and is also patented in Canada and the United States.

Classification and Traffic Regulations for Arkansas Roads

The State Highway Commission of Arkansas has announced a classification of the highways of the state and traffic regulations for them as provided by an Act of the legislature of 1919. The enforcement of the regulations is left to the discretion of the County Judge; the action of the Commission, under the law, being only advisory in respect to the regulations of traffic, as to character and speed. The classification of highways is as follows:

Class 1, all public highways having a hard surface of a total thickness compacted of 7 in. or over, the surface being of portland cement concrete, asphaltic concrete or similar material on a concrete base, vitrified brick on a concrete base, and having a well drained sub-grade. Class 2, all public highways surfaced with penetration macadam, water-bound macadam, gravel, chert, silica or other surfacing material not properly belonging to Class 1 Highways, the surfacing having a total thickness, compacted, of 6 in. or over, and having a well drained sub-grade. Class 3, all public highways which are improved by grading or dragging the earth surface or other roads not properly belonging under Class 1 or Class 2.

The traffic regulations provide that no vehicle, the gross weight which exceeds 12½ tons shall be operated upon the Class 1 highways, nor a vehicle, the gross weight of which exceeds 10 tons shall be operated upon Class 2 highways without a written permit from the County Judge. No regulations were issued for the Class 3 highways.

The following table shows the requirements regarding width of tire and load for horse-drawn vehicles using the Class 1 and Class 2 highways:

Width of tire in inches.......	1	1½	2	2½	3	3½	4	4½	5
Maximum wheel loads in pounds	400	600	800	1,000	1.400	1,800	2,200	2,700	3,200
Maximum load for 4 wheels....	1,600	2,400	3,200	4,400	5,600	7.200	8,800	10,800	12,800

The regulations for motor trucks operating upon Class 1 and Class 2 highways include the following:

No motor trucks or trailers hereafter operating upon Class 1 or Class 2 highways of this county shall have a gauge of more than 75 in. measured from center to center of tires, nor shall be more than 96 in. over all nor over 12 ft. and 6 in. in height.

On the rear axles ¾ of the gross weight of a motor truck or trailer, and of its carrying capacity must be within the limit of the schedules of respective diameter of wheel, size of tires and speed per mile as given in the table below, provided that with the trailers having two wheels, at least three-quarters of the gross weight of the trailer and its load shall be upon the axle of the trailer.

The front axle shall carry the remainder of the weight of a motor truck or trailer and load combined, and must be within the limits given in the schedule below:

TABLE FOR REGULATION OF MOTOR TRUCKS.

Size of tire in inches..	32 Wheel	34 Wheel	36 Wheel	38 Wheel	40 Wheel	42 Wheel	44 Wheel
	Maximum wheel load in pounds.						
2	700	770	840	910	980	1,050	1,120
2½.........	900	990	1,080	1,170	1,260	1,350	1,440
3	1.200	1,320	1,440	1,560	1,680	1,800	1,920
3½.........	1,600	1.760	1.920	2,080	2.240	2,400	2,560
4	1,900	2,090	2,280	2.470	2,660	2,850	3.040
5	2,200	2,420	2,640	2,860	3,080	3.300	3.520
6	2.700	2,970	3,240	3,510	3,780	4,050	4,320
7	3,200	3,520	3,840	4.160	4,480	4,800	5.120

For double tires, multiply weights by 2.

Science and Industry*

By WALTER ROSENHAIN.

If we accept the fundamental idea—that a great joint effort of science and industry is required to achieve the desired result of securing world-supremacy for our industries, what are the principles upon which our organization of science for this purpose should be based? From this point of view, scientific activity in relation to industry may be divided into three great groups or classes, although these must necessarily overlap very considerably. These three great classes relate first to the advancement of science itself, then to the utilization and adaptation of results to industrial uses, and finally, to the detailed application of scientific methods, results, and appliances to the control of industrial processes and products.

Fundamental to the whole edifice of fruitful collaboration of science and industry is the advancement of science itself. We are apt to speak, perhaps with undue boastfulness, of the achivements of science, and undoubtedly these have been great; but even then, we are but able to illuminate a little patch of knowledge in a dark universe full of unknown possibilities. The problem which science has attacked most successfully are probably the simplest among those which nature presents to us—or at least those which, by ignoring inconvenient complications, we are able to picture mentally as relatively simple. In fact, it is this very process of simplifying a problem by isolating its factors and investigating them one at a time which constitutes the most fundamental method of physical experimental science. As a result of this process we have succeeded in isolating a few of the more fundamental principles or formulae by which we can correlate and describe the phenomena of nature, and these we term "laws of nature." But when we come face to face with the practical problems of life, whether in the works or elsewhere, the process of isolating and simplifying problems becomes very difficult.

Practical problems have to be faced and solved as they stand, and although we find ourselves equipped with a certain amount of fundamental knowledge, there is scarcely a single practical problem which is presented to the most expert man of science which does not call insistently for "more knowledge" to allow of its satisfactory solution. Complete knowledge, and therefore the final and complete solution, is not to be looked for—but a little more real fundamental knowledge will make all the difference to the efficiency of the solution that is found. "More knowledge," then, is the real watchword for those who seek for real and lasting progress, whether in industry or science. But how is "more knowledge" to be obtained? Only by fostering and encouraging the highest forms of scientific research, conducted by the few men among us who are really capable of doing such work, without interference or "guidance" from outside. These greater minds work by methods of their own, and must be given every possible facility—material and financial—and all possible encouragement, both intellectual and national. It is not, it may be suggested, for any one industry to bear the burden of such pure scientific research—but since every industry is in the end dependent upon such work of pioneer discovery, each should bear its proper share in providing for such work. Nor should that share consist merely in financial contributions; the really capable scientific investigator is born, not made, and wherever found—be it in a works laboratory or in the workshop—should be regarded as "treasure trove," and carefully cultivated and safeguarded as a national asset. Where men show tastes and aptitudes in that direction, therefore, it is a matter of no small importance that they should be given an opportunity to develop their faculties, and thus to find their rightful place.

Leaders of our industries are ever on the lookout for capable young men who will grow into valuable foremen, managers, or even directors—it is at least as important to remember that among their employes may be one who can advance science by discovery, and thus help to raise our place among the nations. Much might be hoped in this direction from a much wider spread of science as a subject for general education.

We have, then, as our first group or class, those who are engaged essentially on pure research or discovery. Many of these will have little knowledge of, and take small interest in, the practical possibilities of their discoveries; but there are some men who are capable of a second class of activity, which consists in the interpretation and adaptation of the results of pure research to practical uses. In some of its aspects this activity comes into the category usually called "invention." Some workers in pure research may, and do, find their inspiration and their subject-matter in practical questions; provided that they are left entirely free to pursue the paths to which their work leads them, their results may be all the more valuable because of the source of their interest. But such men—capable alike of conducting investigations in the highest branches of pure science and at the same time capable of dealing with practical problems—must, as a rule, be few. What is needed for our proposed ideal organization is, in fact, a group or class of interpreters and adapters, capable of following and understanding the progress of the highest and most abstruse research work, and able to see and appreciate its bearings and possibilities. Such men must be provided with large facilities—well-equipped laboratories and large installations of experimental plant in which they can work out to a practical purpose the consequences which flow from their constant study of the advances of pure science. Among them, or associated with them, must be men capable of carrying further any particular aspect of a purely scientific research which appears to promise developments of interest for the particular industry in question. A certain amount of purely scientific research will thus be carried out among the workers of this group also, but in this case as a secondary rather than a primary purpose.

Closely correlated with this group of "adapters and interpreters" are several other lines of scientific activity which are of very great importance, although secondary in value to the pursuit of pure science and the exploitation of its results. In this category may be placed the more systematic kinds of scientific work which are needed in order to furnish all the detailed knowledge which an industry requires. In regard to non-ferrous metals such questions as the systematic study of the constitution of alloy systems of increasing complexity may be mentioned in this connection—a line of study which would probably be correlated with an examination of as many as possible of the physical properties of the alloys in question. Work of this kind is of the greatest value and importance, since it furnishes many of the fundamental data upon which the use and treatment of alloys must be based in order to meet the increasing stringency of modern requirements. If carried on alone and continuously, systematic work of this kind is liable to become soul-killing for the worker, and he should therefore be encouraged to look for opportunities for work of a more exploratory or pioneering character. In the course of the systematic work he will meet with exceptional cases, unexpected peculiarities of properties or behavior in an alloy, or some peculiar penomenon in its preparation. These anomalies are as a rule the most potent keys to discovery, and the finder of such should be permitted and encouraged to follow up the clue which has presented itself to him, entirely irrespective of the apparent "usefulness" of what he is studying. Neither man of science nor practical man knows enough to tell whether the following of such a seeming by-path may not lead to results of far greater importance than the main issue to which the systematic research is directed.

The group of scientific activities which have been included in this second class which has just been discussed perhaps constitutes the most immediate concern of those connected with industry, and there can be no doubt that work of this kind must be carried out in close touch with the industry concerned. Men working at the adaptation and interpretation of scientific results for the benefit of the non-ferrous metals industry must be thoroughly well acquainted with the processes; and needs of that industry, and must maintain close touch with it, so as to be fully aware of its progress and needs. Ou this ground it will probably be advisable to group with this second class of scientific acitivties a certain number of specific investigations suggested by or aimed at solving specific problems arising out of industrial practice. Workers dealing with such problems in a laboratory in which the "adapters and interpreters" are also at work would serve as a useful link with the everyday life of the industry. This link would be all the more useful because it would not be too close. Any attempt to direct the work of the "adapters and interpeters" too closely into lines which were supposed to lead towards the "requirements" of the industry would tend to sterilize their work—would constitute an effort to direct progress into preordained channels, instead of allowing progress in the industry to follow the natural forward trend of growing scientific knowledge.

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*From Engineering.

It has already been pointed out that among the "adapters," and among those carrying out systematic or specific inquiries or researches, some would tend to follow up paths of pure research opening up from their work. These would form a link with the pure research workers of our first class. On the other hand, others would find more congenial activities in working out the practical applications of the discoveries upon which they had worked. Such workers would find their main interests in the "experimental plant" attached to the laboratory, and might subsequently pass into the works or the works laboratory for the purpose of carrying on the scientific control of the new process which they had worked out on the experimental scale. In this way, the various classes or groups of workers would overlap and feed one another, producing a complete and harmonious system in which science would enrich the industrial soil upon which it flourished.

Finally, there is a third class or group of scientific workers for industry which is quite as essential to a complete and successful organization as the other two. The business of this group or class is to carry scientific methods into the works themselves—not merely into the works laboratory. In the works themselves there is need for a large amount of scientific control—not only of raw materials, intermediate products, and finished output, but also of methods and appliances. This aspect of the subject is, perhaps, better recognized than either of the other two. All the larger works dealing with non-ferrous metals, now possess laboratories, but frequently attention is devoted solely to the chemical analysis and mechanical testing of the metals produced, although the uses of the microscope and the pyrometer have now come to be widely recognized. But the mere establishment of a works laboratory carrying out routine testing, and even making efforts to carry out some research under difficult conditions, is not sufficient to meet the requirements of a satisfactory collaboration of science and industry, even in regard to this one aspect of the subject. What is needed is the introduction and maintenance of scientific method throughout the working processes. To give an indication of the class of activity contemplated, it may be asked how many of those engaged in rolling brass, for instance, are able to give a really satisfactory reason for the size of roll, reduction per pass, and speed of rotation of the rolls they employ?

Personals

J. S. Myers has resigned as superintendent of highways of Hutchinson County, South Dakota.

H. L. Dunn has been appointed superintendent of street construction for the city of Columbus, Ga.

John N. Mackall, chief engineer of the State Roads Commission of Maryland, has been appointed chairman of the commission.

R. M. Miller has resigned as district road engineer for the Utah State Road Commission to accept a position as division engineer of the Virginia R. R. at Norfolk, Va.

Grover A. Blunt has been appointed county engineer of Dubuque County, Iowa, succeeding Myron Downie, who resigned to take a position with the Millard Construction Co.

Alex C. McGregor, L. E. White and H. C. Argo have organized the Dixie Construction Co., of Cotton Plant, Ark., and will engage in a general construction business, specializing in concrete and culvert work in connection with road building.

O. C Lockhart, chief of maps and surveys of the Intermountain District Forestry Service at Ogden, and Ernest Lubeck, a draftsman, have tendered their resignations from the foresty service. Both have accepted positions with the U. S. Bureau of Public Roads.

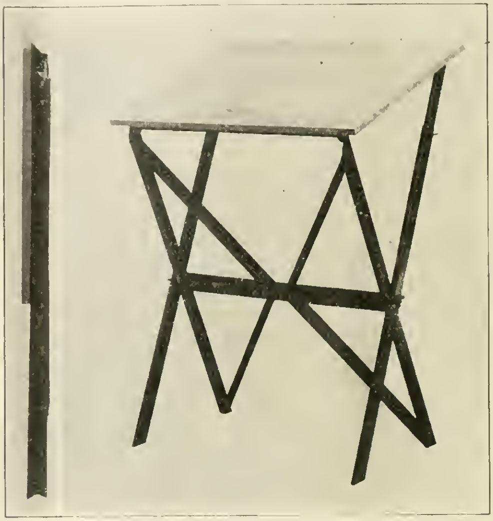
O. V. T. Stoute, dean of the engineering department of the University of Nebraska, has tendered his resignation, to take effect July 1. It is understood he will become affiliated with a business organization at a salary double that he is now receiving from the state.

J. L. Pfeiffer, of Herrin, Ill., has accepted a position at Tacoma, Wash. The firm of J. L. Pfeiffer & Co., mining and municipal engineers, Herrin, has consequently been dissolved, and the instruments and office equipment sold to Pfeiffer & Mallams, consulting engineers, Herrin, Ill.

H. J. Moore, who resigned from the position of chief gardener of the Queen Victoria Park Commission, has been appointed by the Provincial Government Forester of Provincial Highways. His work will largely be the beautification of roadways, by planting shade trees and shrubs along them. His headquarters will be in the Parliament Buildings, Toronto.

A New Folding Drawing Table

A handy folding drawing table, especially designed for architects, students, schools and home use and particularly for conditions requiring a portable table that can be set up and adjusted in a moment's time and as quickly folded up and set away has been invented by H. G. Schaefer, P. O. Box 217, C. I., Toledo. O. The frame is made of formed sheet steel of the cantilever design and is put together to stand extreme weight and strain. The top is made of white pine and fastened to the frame. The adjusting device is an ingenious method permitting the top to be adjusted to any angle and lock securely in position. The table stands 35 in. high and is adapted for any size drawing board from 23 by 31 in. to 36 by 48 in. in size. It folds to less than 3 in. in thickness.



Drawing Table Folded and in Position.

Obituaries

Timothy Foley, a well known contractor of St. Paul, Minn., died May 25 at his home in St. Paul, aged 82.

Thomas Ryan, former superintendent of the City Water Bureau of Chicago, died May 31 at his home in Chicago.

L. J. Putnam, chief engineer of the Chicago & Northwestern R. R., was drowned May 31 at Reed City, Mich., while attempting to rescue his son, who had fallen into deep water.

Industrial Notes

P. J. Healey, specialist in borings for foundations, has removed his offices to the Grand Central Palace, New York City.

H. G. Schaefer has resigned as sales manager of the Economy Drawing Table Co., Adrian, Mich., to accept a position as distributing agent for Ohio, Michigan and Indiana for the Hamilton Manufacturing Co., Two Rivers, Wis. His headquarters and office will be at Toledo, Ohio.

The trustees' report of the pension fund of Fairbanks, Morse & Co. for 1919 shows 8 members pensioned, death benefits of $11,675 and net resources of $505,000, practically all invested in high grade bonds. The fund was established on Jan. 1, 1917, and at the close of 1919 had 1,139 contributing members.

The increased business of J. D. Adams & Co., Indianapolis, Ind., manufacturers of road building and maintenance machinery, has made it necessary for the company to establish several new branches and warehouses in the United States and Canada. New branches have been located at 1106 Cadiz St., Dallas, Tex., 1000 Santa Fe St., Kansas City, Mo., and 501 Kasota Bldg., Minneapolis, Minn.

E. A. Samels, who less than a year ago entered the sales department of the Four Wheel Drive Auto Co., Clintonville, Wis., has been appointed assistant sales manager. Mr. Samels received his early experience with the Chicago office of the Locomobile Company of America, which had charge of a number of the company branches and territory supervision over twenty-four states. Later, he acted as special Chicago representative for A. J. Banta, president of the Maxwell Sales Co.

The corporate name of the Macomber & Whyte Rope Co., Kenosha, Wis., has been changed to Macwhyte Co., effective June 1, 1920. No change in ownership, management or policy of the company is involved. The products of the Macwhyte Co. have for several years been known and advertised under the trade name "Macwhyte." The change therefore brings the name of the company into line with the name of the products. George S. Whyte continues as president and general manager, Jessel S. Whyte as secretary and E. W. Reitzel as treasurer.

Waterworks and Hydraulics Monthly Issue

ENGINEERING AND CONTRACTING

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The four rotated special monthly issues and 4 quarterly issues of E. & C. (52 in all) entirely cover the civil engineering and contracting field at $4.00 a year. Any one of the four special monthly issues may be subscribed for as a monthly at $1.00 a year. The special quarterly issues relate entirely to foreign engineering and construction practice. The *articles* in the first two issues of each month completely cover the municipal engineering and contracting field. The *articles* in the first and fourth issues of each month completely cover county engineering and highway engineering and contracting. The *articles* in the 3rd and 4th issues of each month completely cover steam and electric railway location, design and construction. See the "masthead" on the first page of the Weekly News Section for information about our weekly contract news.

Roads and Streets—1st Wednesday
(a) Roads (c) Street Cleaning
(b) Streets (d) Municipal Miscellanies
(e) Management and Office System

Waterworks and Hydraulics—2nd Wednesday
(a) Waterworks (c) Irrigation and Drainage
(b) Sewers and Sanitation (d) Power and Pumping
(e) Management and Office System

Railways and Excavation—3rd Wednesday
(a) Excavation (c) Quarries and Pits
(b) Management and Office System (d) Steam Railways, Construction and Maintenance
(e) Electric Railway Construction and Maintenance

Buildings and Structures—4th Wednesday
(a) Buildings (d) Miscellaneous Structures
(b) Bridges (e) Properties of Materials
(c) Harbor Structures (f) Management and Office System

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Why Profiteering Has Not Affected the Average Price Level

In a recent editorial the Chicago Tribune said:

> "The Inquiring Reporter," asking five persons picked at random what the Republican platform plank on profiteering should be, received instant and unanimous response that it should be something which would check the profiteers and save the consumers from the high cost of living. If he had been able to ask five thousand or five million persons probably the reply would have been equally prompt, unanimous, and general.
>
> There is little doubt that the high cost of living is at present the most engrossing subject in the minds of the American people. There is no doubt that profiteering is generally considered its chief cause.

The Tribune is probably correct in its estimate that profiteering is regarded by most men as being the main cause of the high price level. Why has this conclusion become so nearly universal? The answer is two-fold: First, because the daily newspapers have printed such an enormous volume of assertion to the effect that profiteering has raised prices. Second, because nearly every individual knows personally of some instance of abnormally high profits having been made.

Looking at these two reasons carefully, we see that neither of them is of the sort that would convince an engineer or any other scientifically trained thinker. The first reason is, in fact, no reason at all. It is mere assertion. But coming from government officials and from editors who are presumably in a position to test its truth by an investigation of the facts, it has been accepted on faith.

The second reason, namely, personal knowledge of a few instances of profiteering, is logically unsound, for it involves drawing a very broad generalization from relatively few instances.

As a matter of fact, such profiteering as exists, or has existed, is a result and not a cause of rising prices; for on a rapidly rising market any buyer of commodities need but hold them a short time to secure an abnormally large profit, and thus make himself a member of the grand order of "unconscionable profiteers."

Profiteering can readily be demonstrated not to be a cause of high average prices of commodities. The total annual money income of a nation is used to buy practically all the commodities produced by that nation during the year. If shoe merchants extort from workmen a larger part of the workmen's income than would normally be paid for the merchants' services, the workmen's remaining income is so reduced as to lessen their buying power or demand for goods that would otherwise have been purchased. The resulting decreased demand for other goods tends to decrease their price. Therefore, by as much as the shoe profiteer has extorted too high a price for the shoes, by an equal amount has he lessened what would have been the price of something else.

Profiteering and extravagance merely divert money income, but do not alter its total. A diversion of money income into purchasing channels other than which it would normally flow raises the prices of commodities in the channels to which it is diverted, but lowers it in the channels from which it has been diverted. That such diversions of money income have produced these results is well shown by the index prices of various classes of commodities. Thus for the month of March, 1920, the wholesale index price of cloths and clothing was 355, as compared with 253 for the average of all commodities, the base price of 100 being that for the year 1913. In other words, the general average price of all commodities was 2.53 times as great in March, 1920, as it was during 1913; whereas cloths and clothing were priced 3.55 times as high as in 1913. On the other hand, the index price for metals and metal products was 192 in March. Hence cloths and clothing had risen almost twice as much as had metals and metal products.

Extravagance and profiteering have existed to a far greater extent in the clothing field than in any other large field, and it is in that field that we find the highest index prices. On the other hand, the demand for metals and metal products has been lessened because of the excessive demand in the cloths and clothing field, and the result has been a proportionately lower price for metals and metal products.

Relatively few men are trained to study prices in all fields. Noting a rise in prices in a few fields with which they are acquainted, and having personal knowledge of some of the reasons for that rise, they leap to the conclusion not only that the same reasons apply to all fields, but that no other reasons exist. This shallowness of thinking springs primarily from lack of training in logic and in applied science; and with it usually goes an almost incredible amount of conceit. The average banker, business man, lawyer or editor is so sure of his power to reason correctly on all ordinary matters, and so sure that price economics is an "ordinary matter," that he will not heed the advice of economists who have made a careful study of prices and the causes of their rise and fall. Indeed, the average man will not even study the history of prices of any previous war period before coming to a conclusion as to the causes of price changes during the recent war period. This cocksureness is typical of the average "educated" man in America, and the reason for it appears to be the failure of most of our schools and colleges to teach logic and applied science with thoroughness. Logic is scarcely taught at all, and as for the science that is taught to any but engineers and chemists, there is not enough to "wad a gun." Shall we wonder, then, at the myriad ways in which the general magazines and daily papers have expressed the prevailing ignorance of the reasons for the rise in prices that has occurred throughout the world during the past five years?

Gen. Black's Criticism of Chicago's Municipal Works and Projects

A few months ago Maj. Gen. William M. Black, late chief engineer, U. S. A., told a Chicago audience some rather unpleasant facts.

Fact No. 1.—That the Chicago main drainage canal is an economic failure in that it is not only delivering putrified water as far down the Illinois River as Peoria, but is diverting so large an amount of water from Niagara River as to cause a loss of 325,000 available horsepower.

Fact No. 2.—That this diversion of water (which he characterized as unlawful) has lowered the level of the Great Lakes half a foot, thus decreasing the tonnage capacity of lake steamers by an amount sufficient to deprive them of half a million dollars revenue annually.

Fact No. 3.—That Chicago is wasting 60 per cent of the water that is being pumped for domestic and industrial uses. He said:

> There are other leaks here in Chicago. There is one little one you probably have not thought much about, and that is the amount of water you pump from Lake Michigan and for which you pay and are taxed The amount of water that should be consumed in a city like Chicago is about 100 gallons per inhabitant per day. Chicago is pumping 235 gallons per inhabitant per day, and I hear you are speaking of increasing that amount. All above 100 gallons is simply wasted, and the money spent for that pumping is thrown away.

Maj. Gen. Black is an able and unbiased engineer. He told the Chicago Association of Commerce some things which, if true, should be very disquieting, at least sufficiently so to lead the Association to employ disinterested engineers to investigate and report upon the matters discussed by Maj. Gen. Black. Yet there has been no action taken by that Association or by any other body of Chicago citizens to verify the alleged facts. Does it not therefore devolve upon the Western Society of Engineers to do what the Association of Commerce has failed to do? Should not the Western Society appoint a committee to study the facts and arguments advanced by both sides relative to the diversion of so great a volume of water through the Chicago Canal?

Gen. Black also stated that Chicago has no real harbor, and that it is an economic blunder to try to make the Chicago River serve as a harbor. In this connection he said:

> The northern end of the Illinois-Mississippi canal is to connect with what is now known as the harbor of Chicago. It has no harbor. The obstructions in the Chicago river, as shown in your own report submitted in 1909, shows it is impracticable to do business effectively in the Chicago river today with its bridge obstructions, its crookedness, and with the few wharves available. It is utterly inadequate as a harbor. The little stuff that is brought in there [illegible] done at an increased cost, with a result that instead of lake commerce coming to Chicago as it used to do, it is now going to Milwaukee. Instead of lake commerce increasing with the years and with the growth of Chicago, it is actually decreasing, and will continue to decrease as long as Chicago attempts to have as her only harbor the Chicago river.

Chicago would be better off, Gen. Black said, if the Chicago river was spanned by fixed bridges of a height sufficient to allow barge traffic to pass through, and if the harbor was put at the lakeside of the last bridge and on the water front.

Speaking ot Chicago's gain in waterpower at the expense of Niagara's loss, Gen. Black said:

> Considering the problem from that phase, and comparing the utilizable fall in the drainage canal and Desplaines river and with that at Niagara Falls and with that in the lower St. Lawrence river, with the present diversion of water from Lake Michigan, 95,700 horsepower can be developed at Lockport and in the Desplaines river, but in doing so it causes a loss of 324,950 horsepower at Niagara and at the St. Lawrence, which at a conservative figure of $40 per horsepower means a potential loss annually to the United States of $13,000,000. In other words, Chicago is not purifying her sewage, and what she is doing is very much at the cost of other people.

Although engineers resident in Chicago may be somewhat biased in favor of engineering projects that may lead to work for them or their friends, we feel certain that such a bias would not be sufficiently strong to prevent a committee of Chicago engineers from coming to a correct conclusion after analyzing all the available data. A committee of engineers should not be asked to work for nothing on a report of this character. The Western Society of Engineers should itself contribute toward the expense of the investigation, and it should secure similar contributions from the Association of Commerce and from public spirited citizens.

One "Boost" for Chicago Water System That Is a "Knock"

Mayor Thompson of Chicago believes in "blowing the horn" to attract attention to the city's merits, but he sometimes "blows" when silence would be a more effective advertisement. For example, huge billboards have recently been covered with posters bearing the following:

> Boost Chicago. We lead the world, pumping more water per capita than any other city on earth and at the lowest cost.
> "WM. HALE THOMPSON, Mayor."

Instead of pride over its great waste of water, Chicago should feel shame. If the city pumps water at a lower cost per foot-pound than any other city, there is, of course, reason for boasting.

That Chicago uses 240 gal. per capita per day, or twice as many gallons per capita as are used by Milwaukee, New York and many other cities is true, but it is a cause for regret rather than for exultation.

During John Ericson's long tenure of office as city engineer, he told the city repeatedly that there was a great waste of water, and that the waste was preventable by metering water consumers.

The present city engineer, P. S. Combs, has submitted plans for doubling the present capacity of the system during the next 35 years at a cost of $60,000,000. He estimates that during the next 20 years the per cent of service meters should be gradually increased from the present 7 per cent until 60 per cent of the services will be metered in 1940.

When that is accomplished he estimates that the daily per capita consumption of water will be 160 gal., or one-third less than it now is.

We fail to see why Chicago should wait 20 years to accomplish this reduction in water waste. It would be far more economic to meter the entire system within the next five years thus reducing the cost per capita consumption 50 per cent or more.

The existing pumping stations represent an investment of about $13,000,000, and Mr. Comb's construction program calls for an additional investment of $13,000,000 in pumping plant before 1940. Some of the plant doubtless will be needed to provide pumping units of greater efficiency. But if universal metering is adopted, the major part of this $13,000,000 can be saved. What is even more important will be the cutting in two of the annual per capita fuel bill, as a result of universal metering.

The investment in the present plant is approximately as follows:

Tunnels and cribs	$22,000,000
Pumping stations	13,000,000
Pipes, mains, etc.	37,500,000
Shops and yards	2,500,000
Total	$75,000,000

The population is about 2,900,000. There are 7 cribs, 64 miles of tunnels and 10 major pumping stations. Only one more tunnel and crib will be needed to provide a total capacity equal to double the present total consumption of water. But to secure this twofold capacity nearly every other part of the waterworks plant must be greatly enlarged. The cost of this enlargement is estimated at $60,000,000, or about five times the cost of metering every service in the city.

In our issue of Feb. 13, 1918, we published an abstract of a report by the Chicago Bureau of Public Efficiency in which it was stated that an investment of $13,000,000 in water meters during the next 33 years would save an investment of $94,000,000 in additional pumps, pipes, etc., not to mention a saving of $69,000,000 in coal, wages and repairs. We have never seen any published denial that these enormous economics can be effected in Chicago by metering. All the arguments against metering are sophistical and based upon unprovable premises.

Engineering societies located in Chicago should support the city engineer in his effort to secure extensive metering of water services, but they should go beyond his modest recommendation that the metering program be spread over a period of 20 years.

Civil Engineers in Massachusetts Civil Service

To the Editor: Not so very long ago, Abraham Lincoln decided to "clean up" the South and abolish slavery. Slavery was annoying, at least, to the negroes and obnoxious to all other people who possessed the faintest conception of true democracy. Under slavery, the negro's desires, hopes and ambitions were rarely ever considered when the swapping and selling of negroes began. If the negro desired to change his job, for one on another plantation, it was his privilege to "desire" a transfer as much as he pleased, this privilege being allowed simply because there was no way to control his thoughts. But an actual change, or transfer, could not be accomplished except by agreement between the plantation owners.

This condition was one of the fundamental reasons that precipitated the Civil War, yet, notwithstanding the tremendous upheaval that resulted, the Massachusetts Civil Service Commission still adheres to the obnoxious rule and practice of permitting the transfer of a civil engineer, from one department to another or from one city to another, only by agreement between the employing officials. Consequently the opportunity for advancement of civil engineers under civil service is controlled entirely by employing officials and the civil service commission. Without kowtowing to his employer, an employe has absolutely no opportunity, consideration or redress in the matter of transferance from one position to another.

A short time ago an employe was not only denied the right to accept another position, but was also abruptly discharged from the position he held for daring to attempt to better himself. Apparently, the opinion still holds that the right to accept another public service position is anybody's business except that of the employe.

Under the laws of Massachusetts, physicians, optometrists, and lawyers are required to pass the state examinations only once in order to practice their professions, but in the same state civil engineers must pass state examinations every two years if they wish to be listed as engineers qualified for public service. At least, the law requires this procedure, although it is violated.

Imagine a lawyer being required to obtain the agreement between the mayors of two cities before being allowed to move his law practice to another city! What would any lawyer think of such a law directed at his profession? What would be the lawyers' attitude if they were required to pass the bar examination every two years simply because they had not happened to practice law during any one of the two-year periods? What would any physician or optometrist think of such conditions imposed upon themselves?

The utter lack of common sense, common law and fundamental rights is clearly in evidence in Massachusetts Civil Service today.

A great deal more might be written concerning other practices that are part and parcel of the present system, that are absolutely beyond all logical reasoning, but unreasonableness doesn't always need accentuating.

THOMAS N. ASHTON.

Fall River, Mass.

Standards of Value

To the Editor: I note Mr. Kimball's question in the issue of May 26th, relative to the use of gold as a standard of value. He does not see how an increase in the quantity of gold in circulation decreases its value because he considers it, aside from its use in the arts, only a measure of value. It is as reasonable, he thinks, to say that because a factory doubled its output of foot-rules there would be only six inches to the foot.

If I understand the writer's position clearly, it seems to me that he may take the editor's reply as only a restatement of the case and not an explanation.

It is generally concluded, as has been remarked in your columns, that the statement to the effect that the purchasing power of gold is in inverse ratio to the quantity in circulation per capita may be taken as axiomatic, and to question it would seem to involve the elements of the theory of exchange. Perhaps the point at issue may be cleared up by going back and discussing barter and the gradual inclusion of the use of money—any medium of exchange—therein.

The early Romans had their flocks and herds and trafficked among themselves, we are informed, on the basis of so much per cow. Cattle were wealth and came to be considered as money for purposes of exchange. "Pecunia" meant money, from pecus—cattle—and the man who was impecunious was undoubtedly hard pressed for his steak, just as he is now. It is conceivable that the flock-masters might some year double the size of their herds, or that the human population they served might be decreased by one-half, in which case when they went to bargain with the men who tilled the soil to raise grain or the men who produced Grade A javelin bronze for the purpose of raising something else, a peculiar situation would be found to have arisen. The cattle, being twice the usual number for the year's trading, and the herdsmen having as many again as they could use, they would compete among themselves for their objects of trade and the value of cattle would be found to have decreased by one-half.

The use of wampum among the Indians and tobacco by the early Virginia colonists as money are notorious examples of makeshift mediums of exchange, or standards of value, in primitive communities. A foot-rule remains twelve inches long no matter how many times it is visualized, but if the Indians who kept their market supplied with wampum had redoubled their efforts it would have taken a fathom of that commodity to do what a yard had accomplished before.

As society advances it prefers the use of the precious metals for money, because they possess portability, indestructibility, divisibility and all that. But they are still commodities and subject to variations in value. In common speech we have terms that are expressive, although inaccurate. We say the sun sets, although it has never done so to date, and that we generate electricity, though that cannot be done, and a man remarks that he is thinking in terms of dollars and cents, when what he means is that he is thinking in terms of the commodities which the dollars and cents equal. A contractor signs up for a hundred thousand-dollar job or laborers agree to work for a certain wage, what they are both thinking of is what the money is worth in terms of commodities, **at that time.** That coolies work for eleven cents per day in China means nothing to us unless we know what eleven cents American will buy in that country.

If Mr. Kimball's theory that gold is an unalterable standard of value were correct, a large portion of human woe would vanish from the earth. Perhaps a remedy is applicable—it may lie so close that we cannot see it—one that would end for all time the evils resultant from a fluctuating standard.

HOWELL V. RICHARDS.

Salt Lake City, Utah.

Water Power Bill Approved by U. S. Senate.—The water power development bill was passed by the U. S. Senate on May 28, and is now before the President for his signature. The bill provides for a commission to supervise the development of water power on navigable rivers under licenses granted to individuals and corporations. The government is to have a prior right to develop power and upon the expiration of a license to private capital the government reserves the right to take over any power properties, paying therefore not more than the original cost. The government also reserves the right to take over any power property at any time under condemnation proceedings and to operate plants in time of public danger.

Modern Tendencies in Railway Water Supply

The estimated annual consumption of water by the railroads in the United States is approximately 900,000,000,000 gal. The cost of furnishing this water, not including interest and depreciation charges, will average over 7 ct. per 1,000 gal., making a total annual expenditure of more than $63,000,000 for water. To supply this water it is necessary to maintain approximately 13,000 water stations for locomotive supply in addition to many connections for general service. These facts and many others have been collected and summarized in an interesting paper read before a recent meeting of the Western Society of Engineers by C. R. Knowles, Superintendent, Water Service, Illinois Central R. R., Chicago.

An analysis of the consumption of 15,622,000,000 gal. of water on a middle western railroad indicated that 23 per cent, or 3,600,000,000 gal., was purchased from 232 cities and private waterworks plants and 12,022,000,000 gal. pumped by 230 railroad pumping plants. A further analysis of the various uses of this water indicated that locomotives consumed 74 per cent, or 11,560,280,000 gal.; washing and filling boilers at terminals used 12 per cent, or 1,874,640,000 gal.; 5½ per cent, or 859,210,000 gal., was required by stationary power plants, and 8½ per cent, or 1,327,870,000 gal., was used for sanitary and domestic purposes.

There has been a marked development in pumping equipment used in railway water stations within the past few years. The gasoline engine was a popular power unit for railway pumping stations for a time, but it was really never a serious competitor of steam except at the smaller stations and at points where the cost of pumping with coal was excessive. Electricity has become available in many communities at rates sufficiently attractive to warrant serious consideration, with the result there has been considerable use of electric motor drive for pumping plants. Automatic control with the elimination of the expense for constant attendance is responsible for the increasing use of electric drive. Oil engines of the so-called semi-Diesel type are being used extensively and are proving very satisfactory and economical. Oil engines operating on the lower grades of oil have been perfected to such an extent that their operation is practically as reliable as steam. The oil engine and centrifugal pump make an ideal pumping unit. The cost of fuel will vary in different localities, but there is scarcely any place in the country where oil will not compare favorably with coal in operating a pumping plant.

Storage is an important feature of railway water service, but unfortunately it is a detail that has been much neglected in the past. Up to within the past few years the standard roadside tanks rarely exceeded 50,000 to 60,000 gal., although the standard roadside tanks today include those with a capacity up to 200,000 gal.

The amount of storage available is an important factor in the operation of a railway pumping station, as the expense of operation can be doubled easily through the necessity for employment of additional pumpers by reason of the tank being too small to carry over the night hours, notwithstanding the fact that the equipment may be large enough to pump all of the water required during the day shift.

One important development along this line has been the use of treated timber for the construction of tanks. On certain railroads favorably situated the creosoted tank has proved a very profitable investment, as the first cost of construction has been much less than either an untreated tank of more permanent timber or the steel tank. While these tanks of treated timber have not been in service long enough to determine their useful life, there is every reason to believe that their life will be as great as that of the best untreated timber and the maintenance of a treated tank properly framed before treatment much less than either the untreated timber tank or the steel tank.

One decided advantage possessed by the modern conical bottom or hemispherical steel tank over the wooden tank or flat bottom steel tank is the removal of suspended matter carried by the water, through precipitation. There is a great need for a simple type of settling basin or filter for use in connection with the wood tank, as the removal of the suspended matter from water supplied from a stream before it enters the locomotives will effect material economies in boiler repairs and washouts.

There has probably never been a time when more interest has been displayed in the treatment of locomotive water supplies than within the past two or three years, the reason for the increased interest in water treatment being, of course, due to the greatly increased cost of fuel and boiler repairs and the importance of keeping locomotives in service. It is only too true that the treatment of locomotive boiler supplies has been neglected, as may readily be seen by comparing the amount of water treated with that requiring treatment. While there is no complete record of the number of water-treating plants in service on the railroads of the country, a fairly accurate estimate would be in the neighborhood of 600 plants, and from the known capacity of some 200 plants the average amount treated by each plant is 36,000,000 gal. per year, or approximately 21,600,000,000 gal. of treated water is used annually on railroads.

Assuming that 80 per cent of the total consumption, or 720,000,000,000 gal., of water is used by locomotives and power plants and that 50 per cent is of such quality that treatment would be economical, it means that we have less than 6 per cent of the treating plants in service that are needed. It is only necessary to check the reports of the results obtained from treating plants on those roads having them in service to be convinced that there are few investments that can be made on a railroad that will show quicker or greater returns than a properly designed and operated water-softening plant.

The United States Fuel Administration stated in its Engineering Bulletin No. 3 that it has been estimated that the use of hard water in a great number of the locomotive boilers of the country involved the consumption of 15,000,000 tons of coal more than would be needed if soft water only was used.

The Illinois Central R. R. has been making a campaign against water waste for the past 5 years, with the result that the saving during this period has amounted to $326,900, or an average of $200 per day. This has been accomplished by investigating every possible source of waste and keeping the importance of the subject constantly before officer and employe. The principal saving was made in the cost of city water, and efforts were directed chiefly toward correcting the waste of water purchased from outside parties.

A trained organization is also essential for the proper functioning of railway water supply stations. Providing water for locomotives and other railway purposes is a feature of railway operation that varies more widely than any other department. The development of an adequate water supply, the economical and efficient design and construction of water stations together with efficient supervision over maintenance and operation are problems that require the undivided attention of a staff trained in water service work. The results obtained by roads that have established a water department have shown conclusively that there is an urgent necessity for an organization to handle this very important feature of railroad operation.

Method of Stopping Leaks Due to Cracks in Concrete Lined Reservoirs

Methods that have proved very satisfactory for stopping leakage from concrete-lined reservoirs are cited by Charles Haydock, Engineer, Mountain Water Supply Co., Philadelphia, in the May Journal of the American Waterworks Association:

One of the most successful methods has been to open the crack by chipping and placing sections of 1½ in. pipe at proper intervals. The crack between the pipes is filled with a rich, strong grout and, after this has thoroughly set, neat cement grout is pumped through the pipes to refusal, taking care that the pressure does not approach that which would blow out the grout placed in the crack or lift the concrete. A small, ball-valve, hand pump, such as is used for spraying fruit trees, has been used very satisfactorily for this purpose.

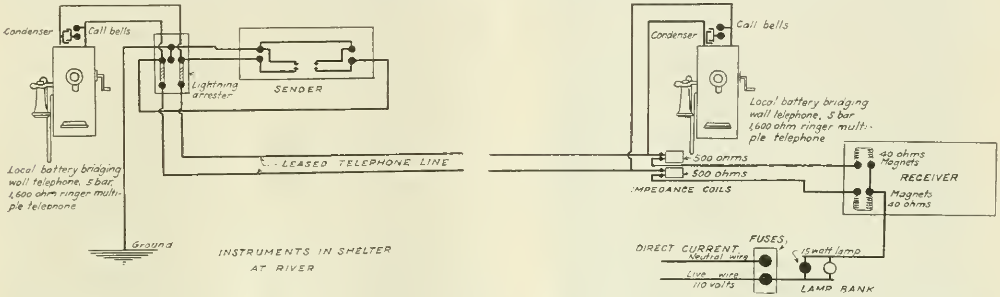
Where the cracks are very small and there is not much current in the reservoir, excellent results have been secured by inducing coagulation in these cracks. In several cases where the water was turbid, alum, sown broadcast, has been sufficient; in other cases it has been necessary to use lime to raise the alkalinity and also to introduce a mixture to supply the material which is to be coagulated in the cracks.

In the case of small, concrete chambers, hemp and lead wool have been calked into the cracks. Very satisfactory results were secured by this method in a concrete penstock, serving two small water turbines.

The Development and Use of the Long Distance Water-Stage Recorder

By ROGER C. RICE.

The satisfactory operation of a long distance water-stage recorder at the United States Geological Survey's stream-flow measuring station on Kansas River at Topeka, Kan., marks a decided improvement in the design and development of this type of instrument that broadens the scope of usefulness of water-stage recorders in hydraulic engineering, and suggests other practical adaptations.



Wiring Diagram for Gurley Long Distance Water Stage Recorder Equipped with Two Telephones with Call Bells for Stream Flow Measuring Station on Kansas River at Topeka, Kan.

Water-stage recorders for obtaining continuous records of fluctuations in water level have been extensively used during the past 10 years. The importance of their use on engineering projects is generally recognized. These instruments have been improved from time to time and perfected so that at the present time there are several reliable makes on the market, adapted to a wide range of conditions. The long distance recorder, on the other hand, is a comparatively recent development.

The sending instrument of the long distance water-stage recorder, located at the point of observation, "telegraphs" continuous records of fluctuations in water level to a distant point over an electric circuit by means of the make and break principle used in telegraphy. The receiving instrument accurately reproduces these fluctuations on a water-stage recorder or on an indicating dial. In this way the instrument overcomes the handicap of distance and keeps the chief engineer at his office or the plant operator fully informed regarding all changes in stage taking place at the distant station. These instruments now form an integral part of the equipment of many hydro-electric power plants.

Other organizations also find this type of recorder of practical value in securing records of fluctuation in streams, canals, surge tanks, etc., where the point of observation is not easily accessible. The installation by the United States Geological Survey at Topeka will serve as a typical illustration.

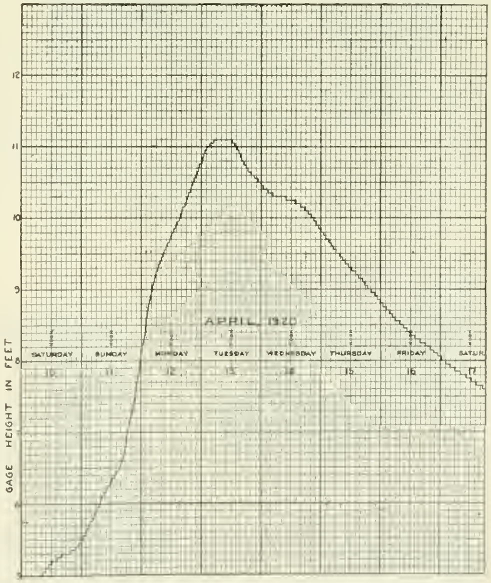
The river forecast work of the United States Weather Bureau in the Kaw Valley in Kansas is handled by the local office at Topeka, under Mr. S. D. Flora, Meteorologist, who has worked out a comprehensive system for flood warnings. During high stages of the Kansas River his office, located about ½ mile from the river, is besieged for latest information regarding river stages. Prior to 1919 the office depended on a gage observer for this information.

The United States Geological Survey, in co-operation with the Kansas Water Commission, in 1917 began an investigation of the flood problems of Kansas, especially that presented by Kansas River and its tributaries. Several stream-flow measuring stations are maintained, one of them located on Kansas River at Topeka. As the stream-flow investigations of the Geological Survey are closely related to the flood forecast work of the Weather Bureau, the two bureaus planned to co-operate in the installation of a long distance water-stage recorder. With the receiving instrument located in the Weather Bureau office, a continuous record of the river stage would be available at all times and the rapidity of the rise and fall during periods of high water and the progress of flood crests could be determined readily from the graphic record.

Through the courtesy of W. & L. E. Gurley of Troy, N. Y., makers of hydraulic instruments, the Topeka gaging station was equipped, in the fall of 1918, with an experimental long distance water-stage recorder of recent design.

The performance of this instrument was critically observed both by Mr. Flora and the writer. Independent investigations were carried on by the makers at their experiment station on the Hudson River at Troy, N. Y. The knowledge gained and the improvements made in these installations operated under typical conditions resulted in the development of a simpler and more reliable instrument of the type now in operation at Topeka.

The sending instrument at Topeka is located in a concrete shelter over a reinforced concrete stilling well on the river bank. It is connected to the receiving instrument by a pair of wires leased from the telephone company. The sender is grounded and operates the receiving instrument by means of these two wires and a "ground" return. One circuit "telegraphs" rising stages, the other falling stages. Current is supplied to these circuits from a 110-volt D. C. power line at the Weather Bureau office.



Graph of River Stages on Kansas River at Topeka, Kan., April 10-17, 1920, as Recorded by Receiving Instruments of Gurley Long Distance Water Stage Recorder.

A phosphor bronze tape attached to a 21-in. diameter float and counterweight passes over the sprocket wheel of the sender to which are geared two bent metal contact tubes containing mercury. Each tube is divided longitudinally by an insulated partition having openings near the bent end. One side of the tube connects with a ground wire, the other to a line wire. One tube operates on rising stage, the other on falling stage. As the float fluctuates up and down in the stilling well with the changing river stage, these contact tubes swing through small arcs and make electric contacts whenever the stage rises or falls one-twentieth of a foot. At that instant, a steel pawl releases its control over the movement of the unbalanced contact tube, which swings quickly back to normal position. This causes the mercury to rush to the bent end, where a mercury-on-mercury surface contact is made. These tubes have been severely tested with heavy loads of 120 volts without any failure or sign of deterioration, and insure positive, sparkless contacts. The sealed tubes insure at all times clean mercury contacts.

U. S. Geological Survey Stream Flow Measuring Station on Kansas River at Topeka, Kan. The Sending Instrument of the Long Distance Water Stage Recorder Is Located in the Reinforced Concrete Well and Shelter.

The sprocket wheel of the sender also forms part of an indicating gage for recording the gage heights in the stilling well. The wheel is 1 ft. in circumference and is divided into 100 parts, and the feet may be read conveniently on a counter.

The receiving instrument used at Topeka is a Gurley 7-day water-stage recorder, modified so that the record cylinder is operated by magnets instead of directly by the float. The drum is turned by means of gears and a rachet wheel is operated by two pairs of magnets, one for rising, the other for falling stage. The operating arms, which are attached to the magnet armatures, turn the ratchet wheel one notch each time either magnet is energized, corresponding to a change of stage of one-twentieth of a foot at the sender. These arms also are provided with interlocking stops that prevent the wheel from turning more than one notch, until the magnet is released and ready for the next step. The magnets are wound for a resistance of 40 ohms and require but 0.1 ampere for their operation.

The graphic record made by the pencil which is operated by an 8-day clock shows every half-tenth foot change in stage throughout the week that occurred at the sending instrument. When the stage changes rapidly the time interval between steps is short and the stepped pencilgraph approaches a continuous line.

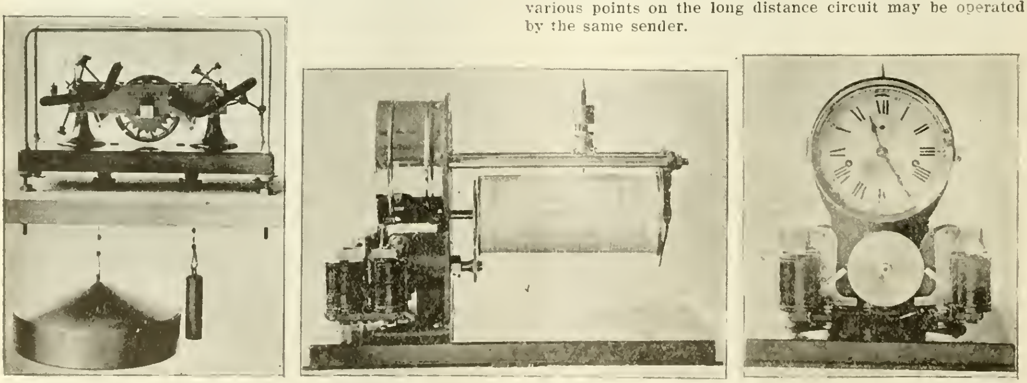
A unique feature of the Topeka installation is the use of the wires of the long distance recorder for inter-communicating telephones at the sender and at the office, without interfering in any way with the operation of the recorder. Telephones for use in inspecting or adjusting the performance of the instruments are most desirable. Use of the wires of the long distance recorder for telephones, especially when the sending instrument is in a location remote from other telephone service, saves the expense of installing and maintaining a separate telephone line.

Although it is a simple matter to equip the long distance recorder with telephones without call bells and ringers and to signal through the sender, it is more convenient and efficient to install fully equipped telephone units at both ends of the line. This has been accomplished in the installation at Topeka by inserting a 500-ohm impedance coil in series with each of the line wires. In this way, telephone units equipped with magnetos and ringers are operated in the usual way. The impedance coils prevent disturbance of the sensitive magnets of the receiving instrument by the alternating current generated by the action of the ringer. The slightly increased line resistance offered by the impedance coil is adjusted at the lamp bank on the power line. Small condensers inserted in series with the call bells of each telephone prevent the possibility of the impulses from the sender crossing through the call bell circuit to operate the wrong set of magnets of the receiving instrument.

Although this arrangement of the long distance water-stage recorder at Topeka is a typical installation, several modifications of this type of recorder are possible.

The recording gage may be replaced by an indicating dial with a moving pointer that is operated by the electro-magnets and the ratchet wheel in the same manner as the recorder. The dial shows the stage at the distant observation station at any instant.

Several recording gages and indicating dials located at various points on the long distance circuit may be operated by the same sender.


Sending Instrument

Receiving Instrument, Side View.

Receiving Instrument, Front View.

Gurley Long Distance Water Stage Recorder.

Many combinations of these instruments may be worked out in connection with the operation and regulation of water supply systems, hydro-electric power plants, or other enterprises, and the recording gages or indicating dials concentrated at a central station where the performance of the interrelated units may be readily observed and effectively controlled.

Protection of Small Motors in Pumping Plants

Ways for protecting small motors, such as are used in pumping plants and in small industrial applications, against high temperatures and low speed, were described in a subcommittee report presented by G. E. Armstrong at the recent convention of the National Electric Light Association. The matter following is abstracted from the report.

The proposition of low speed involves many factors. It includes low voltage or no voltage, loss of solder in end rings, overloading, scraping of rotors, and low frequency. Nearly all of these features will result ultimately in high temperatures. Loss of solder in end rings and scraping of rotors will, of course, result in a more rapid rise in temperatures than will low voltage, low frequency or overloading.

As long as a motor performs its duty and does not reach dangerous temperatures, there appears to be no good reason why it should automatically be taken off the line; that is, overheating for a period of time which does not permit of permanent injury to the winding is of no consequence. If the voltage dips to zero for a moment and again returns to normal without having permitted the speed of the motor to go to such a low limit that it will not again be able to obtain normal speed without drawing such heavy currents as might injure it, the motor should not be disconnected from the line.

This particular feature is of considerable interest at this time, since the use of apparatus to do this duty would be in a large way a justification of the use of expensive installations to shorten or eliminate interruptions; that is, if the proper protective relay systems were installed on the transmission system, a short circuit would merely result in a momentary dip in voltage on the system during the time between the occurrence of the short and the opening of the proper switches to remove it. At present it is required that motors be equipped with low voltage relays which are usually set to operate instantaneously on a decrease in voltage of 50 per cent to 75 per cent of normal. With equipment such as this installed, the result is that a short circuit even of a very short duration causes the load to be dropped due to the operation of the low-voltage releases.

If the motors were protected by a device which would permit the opening of the switch only when the speed of the motor decreased too low, then the resumption of normal voltage would allow the motors immediately to pick up the load and the consumers would suffer no interruptions. The present practice is particularly reprehensible when applied to pumping plants, due to the fact that many of the motors lose their prime when they stop and the low water level makes it impossible to start up without waiting for the water to rise in the wells. Interruptions of considerable length are suffered by the consumers, due to a very brief interruption in voltage.

Information has recently come to hand regarding the method of protection of motors in precious metal mines. It has been found that it was impossible to apply any of the present known protective devices to these motors. Even the use of fuses and circuit breakers was unsatisfactory, since it was necessary to use fuses of such large capacity or set the instantaneous automatic overload breakers at such high values of current that they were useless in protecting the motors against overloading which, while not of sufficient magnitude to blow the fuses or open the switches, was great enough to damage the motors. The reason for this state of affairs was that the motors were very commonly called upon to carry loads greatly in excess of normal, due to heavy starting conditions when the machinery had been idle for a period, or when jams occurred due to the nature of the material handled.

However, it was brought out that some form of thermostatic protection would have been desirable since a large part of the trouble was due to overloading.

The conclusions to be drawn are that satisfactory devices intended to operate at predetermined low speeds to cut the motors off the line, and suitable thermostats for application to the motors would give the most desirable protection for such motors.

Flexible Joints and Methods of Laying Subaqueous Water Mains

At a meeting last fall of the New York Section of the American Waterworks Association, three interesting papers dealing with the construction of subaqueous water mains were presented. A paper by Patrick Quilty, Assistant Engineer, Department of Water Supply, Gas and Electricity, described the laying of a 12-in. main to North Brother Island. The construction of the Narrows Siphon from Brooklyn to Staten Island was described by John P. Hogan of Parsons, Klapp, Brinckerhoff & Douglas, Engineers, New York City. The third paper was presented by Francis H. Sherrerd. It dealt with the construction of two lines of 30-in. flexible joint subaqueous pipe under the Hackensack River, New Jersey. The matter following is abstracted from the above papers.

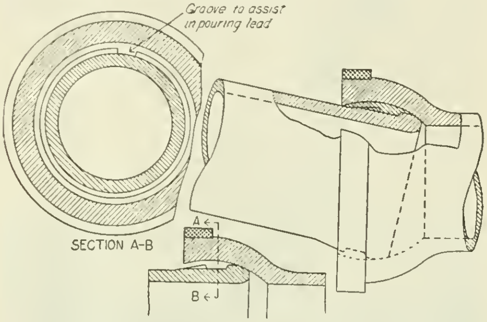


Fig. 1—Flexible Joint for North Brother Island Main.

Flexible Joint for North Brother Island Main.—The North Brother Island main crosses the East River from East 140th St., New York City. The distance across is approximately 1,700 ft. and the actual length of the pipe line between valves is 1,843 ft. The type of flexible joint used is shown in Fig. 1. In the 10 days from Oct. 14 to Oct. 23, 1915, inclusive, 113 lengths of pipe were laid. Each length is 12 ft. and weighs approximately 2,400 lb. The force consisted of 1 foreman, 4 sailors, 1 calker, 1 leadman, 1 engineman and 1 night watchman. Besides a lighter, a tug and a row boat were in use. The depth of the river at the crossing was 80 to 90 ft.

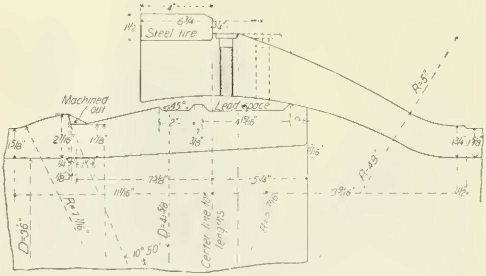


Fig. 2—Flexible Joint Used on Narrows Siphon.

General Features of the Narrows Siphon.—The Narrows siphon built by the Board of Water Supply of New York City is a 36-in. flexible-joint cast-iron pipe line laid across the entrance to New York Bay from Brooklyn to Staten Island. The minimum depth, except at the approaches, is 60 ft. below mean low water, and the maximum depth at the center of the channel is 74 ft.

The siphon crosses the Narrows, as the entrance to the Bay is called, at a section where the shipping in and out of the Bay is very active, and where there are two anchorage grounds, one for merchant vessels and one for war ships. The government regulations prohibited refilling the pipe trench above an elevation 45 ft. below mean low water. The pipe line had to be protected by at least 8 ft. of backfill, which made it necessary to place the bottom of the pipe at least 56 ft. below mean low water. This great depth rendered work on the bottom so difficult that it was considered preferable to lay the pipe in a continuous line by means of a cradle rather than to make up several lengths at the surface and joint these sections together after they were lowered to the bottom.

Flexible Joints for Narrows Siphon.—The angle of deflection of the joints in laying by means of a cradle was about 5°, enough to destroy the effect of any ordinary calking of the lead in the joints, since the effect of this calking rarely extends farther than about ¾ in. into the lead, while the maximum movement of the spigot inside the hub was about 2 in. If the calking were done in the usual way before the pipe began its movement down the cradle, the effect of the bending of the joint would be to loosen the lead so that after the pipe reached its final position on the bottom it would be necessary to calk the joint again. To do this in such a depth of water would be very difficult. Experiments were accordingly made to ascertain if it were possible to design a joint which would permit the necessary motion and yet remain tight. It was not possible to find any material which did not shrink in cooling and thus make calking necessary. Joints calked with lead wool proved tight but were not flexible. It was finally decided to pour the joints in the usual way and then attempt to calk them by forcing in lead pellets under great pressure to compensate for the shrinkage of the lead joint in cooling, estimated at about 10 per cent.

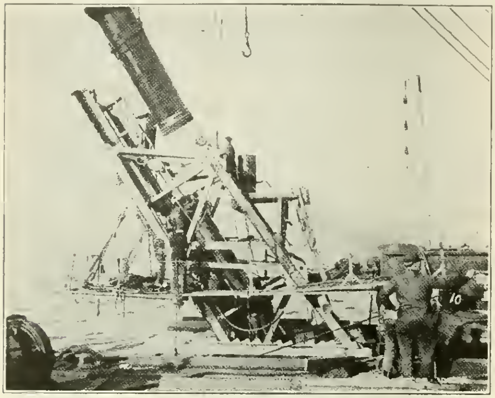


Fig. 3—Making Up a Joint.

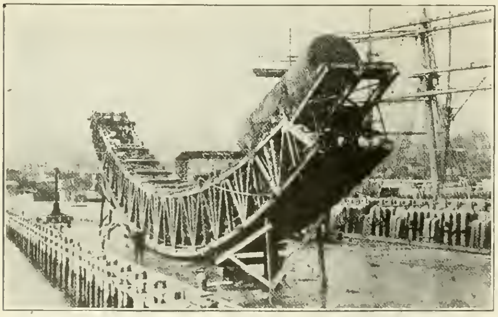


Fig. 4—Cradle with Float at Lower End.

The details of the joint as finally worked out are shown in Fig. 2.

Method of Making Joint and Laying Pipe.—The joint was made on the deck of a scow, as shown in Fig. 3. The inside of the bell was first coated with graphite. After the spigot of the next length of pipe had been centered in place, the lead was poured into the joint, about 280 lb. being used. Three cylinders of lead, each 9/16 in. in diameter and ¾ in. long, were forced by compressed air into each of the back holes and one into each of the front holes. Grease to which 10 per cent of graphite had been added was forced into each hole and the big screws driven down. About 24 lb. of pellets were used in a joint. The joint was then deflected 5° and tested under a hydraulic pressure of 100 lb. per square inch before it was launched.

The pipe-laying scow was 40 by 125 ft. with a 70-ton derrick. It was held in position by ten anchors. Originally the cradle was swung from this derrick over the side of the scow, but later it was carried by cables running over a trunnion at one end. The cradle was built of structural steel, as shown in Fig. 4. It was 168 ft. long, 8 ft. wide and 10 ft. high, and weighed nearly 60 tons.

The pipe was so tight when laid that no satisfactory measurement of the leakage could be obtained. The only trouble experienced was in the early stages, when the pipe was tested under a pressure of 120 lb. to the square inch with one end free in the cradle. One of the joints just beyond the end of the cradle buckled and was straightened and replaced by a harness and recalked with lead wool by divers.

In dredging the trench about 450,000 cu. yd. of material were removed, the maximum depth of trench being about 38 ft. In general the material, fine sand and silt, stood on slopes of 2 horizontal to 1 vertical, with a bottom width of 20 to 30 ft. The trench was smoothed before laying by towing up and down a V-shaped drag similar to a snow plow. The pipe was covered with from 8 to 10 ft. of refill.

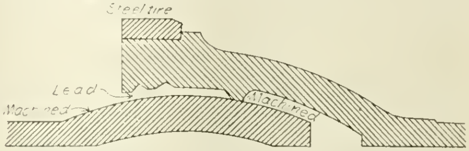


Fig. 5—Flexible Joint for Hackensack River Pipe.

Soundings taken one year after completion indicated that the unfilled trench above the refill is moving upstream, but there is no scouring at the bottom into the cover refill. The trench did not seem to be filling up at that time.

The whole 10,000 ft. of pipe line was laid in two working seasons. At the end of the first season's work the cradle was pulled out from under the pipe and at the beginning of the next season's work the cradle was launched so that the rear end came within about 2 ft. of the pipe already in place on the bottom. The pipe was then made up and allowed to slide down the cradle until it entered the bell of the last length laid. This joint was drawn together by a harness and calked with lead wool by divers. The harness was left in place.

Flexible Joint for the Hackensack River Crossing.—The Hackensack River crossing is about 1,800 ft. in length. The Snare & Triest Co., New York City, were the contractors. Class D pipe with a modified Ward or Metropolitan type joint (Fig. 5) was used. The spigot end of the pipe is ball-shaped, machined to a true surface and limited to within 1/32 in. of the prescribed diameter with a slight rise to the barrel of the pipe at the inner end to act as a bumper in case of an accidental deflecting of the pipe to a greater angle than the 10° allowed in the specifications.

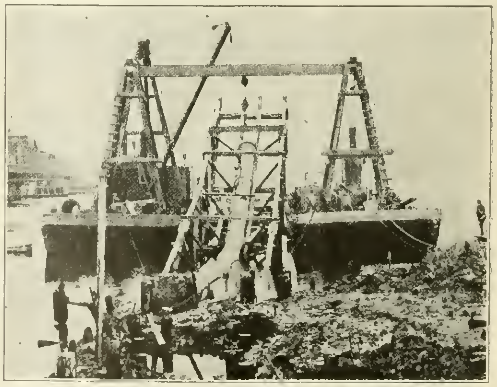


Fig. 6—Beginning of Subaqueus Pipe Laying.

The bell end is a socket with a ring machined to the same shape as the ball 6 in. in from the face of the ball and about

¾ in. wide, straight on the inner side and sloping on the outer. Two grooves were cast in for the lead. A steel tire was shrunk on the bell end to give greater strength. It was thought best to use this type of joints as, after calking, the lead remains in the socket end and the ball moves in it and requires less care in lining up the pipe before making each joint and also makes it much easier to calk up all leaky joints.

The average amount of lead used per joint was 155 lb., and the depth of joint about 5½ in., as one strand of yarn was used.

Great care was used in handling the pipe to prevent scarring the balls. The machined surfaces were carefully scraped and cleaned and oiled before laying. Any sandholes or defects which passed the inspection at the foundry were repaired by boring small holes, larger at the bottom than top, and filling with babbitt metal.

Method of Laying Pipe.—The floating equipment consisted of two large derrick scows carrying an air compressor and pumps, one deck scow, one large launch and a large cradle from which the pipe was laid, Fig. 6.

The cradle was built of timber, firmly braced and bolted, with a curved track to carry the pipe. The track rested on eight 12-ft. members, chords of an arc of a circle of 86 ft. radius, each segment being 8°. The long chord at the top of the cradle was about 91 ft. The width of the cradle over all was 16 ft., and that of the tracks about 2 ft. 6 in.

The cradle was swung between one derrick scow and the deck scow in such a manner as to allow easy raising and lowering to prevent too great deflection of the pipe at the bottom of the cradle, caused by the motion of the tide, and also to remain within the limit of deflection on the slopes on each side of the river.

The plans required the laying of the two lines on 20-ft. centers and a trench 40 ft. wide on the bottom was dredged at a depth of 32 ft. below mean low water between pierhead lines. From the pierhead line to the shore on one side of the river an easy slope of approximately 10 to 1 was possible, but on the other it was necessary to make it about 4 to 1. As this was at the far end of the work, it was quite difficult to carry the cradle at the right angle to keep the foot of it so that the slope would be tangent to it. All mud was removed and replaced with sand and clay and the uneven bottom smoothed out within reasonable limits. About 100,000 yd. of material was dredged.

One derrick scow was used to load pipe at the dock and to assist in the handling of the cradle. The two other scows firmly lashed and carrying the cradle were anchored in such a way as to carry the center of the cradle in line with rangers set on the shore.

One length of pipe at the start was made fast in an anchorage of piles on the shore. Next two sets of two lengths each were made up on the deck of a scow and lowered in line. Then the joints were poured and calked and the whole laid on the lower end of the cradle, the upper end of the cradle having been hoisted high in the air. After that each length was laid separately in the cradle and lashed securely so that the whole might not slide. The bell end of the last length laid was blocked off the curved track so that the spigot end of the one to be laid could be lowered in, leaving the two in nearly a straight line. Care was taken to see that the last joint made was not deflected too much. The joint was then made and calked hard, the block taken out and joint broken by lowering it into the curved track again. The lashing on the pipe was then loosened and scows and cradle moved back in line by tightening and loosening anchor lines.

In going up the slope on the far side of the river, more trouble from leaky joints was expected owing to the natural pushing of the ball into the socket and possible pushing away from the lead, but by careful calking this was overcome and only three or four leaks of any consequence resulted, although as a result of the hard calking it was much more difficult to break the joints.

On the first line the use of the cradle was stopped at about six lengths from shore and it was pulled out with an end and side motion, moving the pipe, without intention, to the limit of deflection in two joints, which, in combination with the action of the tide when the pipe was suspended from a derrick, caused them to leak and made it necessary to calk them again. The last three lengths laid were then suspended from one derrick scow and the remaining lengths laid from the other.

At the end of the laying of the second line, the cradle was unbolted in the middle and taken out in two pieces so that the pipe was not disturbed.

Each day's work was inspected from the inside and any dripping joints or bad bends were noted.

This was done by lowering a man down the pipe from the cradle end and, although it required great physical effort, proved much more satisfactory than diver's inspection. From the shore ends the pipe on the slope was easily inspected down to the place where water leaking through the bulkheads would make it inconvenient. The shore ends of the pipes were below high water and often the bulkheads were not perfectly water-tight.

It was found easily possible to repair leaks from the inside, but where more than two or three appeared it was cheaper to repair by calking by divers on the outside. It took considerably more than 100 lb. of lead wool to repair a small leak on the inside and on account of cramped quarters and the curved shape of joint took too long a time.

The first line was laid at the rate of 6.8 lengths per day and the second at 7.9. The best day's work was 18 lengths, and a rate of 12 lengths per day could easily have been maintained after organization had it not been for delay in dredging and bad weather.

The force required for laying consisted of 3 calkers, 3 riggers, 3 engineers, 4 laborers.

The specifications required both air and water tests. Nearly all leaks showed at 10 lb. air pressure. The pressure was finally raised to 70 lb., but all leaks that showed at 70 also showed at 40.

On the first line, after repairing all visible leaks, the pressure was raised to 72 lb. at 4 p. m. At 8 the next morning it was 61 lb. On the second line at 3 p. m. the pressure was raised to 70 lb. and at 8 the next morning was 55 lb., in spite of an air leak in one of the valves.

The water leakage allowed amounted to about 1 cu. ft. a minute for 24 hours. The leakage was so small that the pumps could not be run slowly enough to exceed the required pressure.

Stopping Leakage in Concrete Reservoir by Calking with Lead Wool

A method which has given good satisfaction in stopping leakage in concrete reservoirs is described by W. N. Jones, chief engineer, design and construction, filtration plant, Minneapolis, Minn., in the May Journal of the American Waterworks Association:

The cracked or honey-combed portion is first cleaned, by means of chisels, of all loose and broken material. Great care is taken to do the job in a first-class manner. In case the crack is very small, then it has been Mr. Jones' practice to enlarge this crack to a depth of about 1 or 1½ in., making the enlargement in the form of a V. After the concrete has been prepared in the above manner, lead wool was driven into the crack or porous portion of the concrete by means of a suitable calking iron, very much in the same manner that the lead is calked in the joints of a cast iron pipe, using only a small portion of the lead wool at a time and continuing the process until the crack is completely filled even with the surface of the concrete on the two sides. Care must be exercised to see that the lead wool is well driven into place and forms a homogeneous mass instead of merely being shoved in haphazardly. When finished the crack appears exactly like a calked joint on a hub and spigot cast iron pipe. This method has been used on both inside and outside of structures so that the pressure may tend to either hold the lead wool in place or to push it out of the crack. Although this method of stopping leaks has been used for the last six or seven years, no job has had to be done over a second time. Of course, unless the concrete is dense and of a good mixture this practice is not recommended, but with a good 1:2:4 mixture, properly mixed and placed, it has given a great deal of satisfaction at a very reasonable cost.

Two Republican Presidential Candidates Now Members of A. A. E.—Herbert Hoover, chairman of the American Relief Commission and president of the American Institute of Mining and Metallurgical Engineers, has applied for membership in the American Association of Engineers. The membership number assigned to Mr. Hoover is 20,000. General Leonard Wood, who is also a member, has membership number 10,000. The association has not declared itself in favor of either General Wood or Mr. Hoover as possibilities for the presidency.

Proposed State Hydro Electric Development in South Dakota and Detailed Estimates of Cost

The power possibilities of the Missouri River in South Dakota and the various sites at which hydro-electric power might be developed have been investigated by Daniel W. Mead and Charles V. Seastone, Consulting Engineers, Madison, Wis. The investigation was made for the Hydro-Electric Commission of South Dakota, acting under a statute approved Feb. 26, 1919, which provided that :

> The state may purchase, own, develop and operate plants for the development of power, upon streams of this state and at coal mines upon lands owned by the state and may transmit such power and supply the same to the people of the state. The state may pledge such plants and the accessories thereto to provide funds for such purchase and development, anything in this constitution to the contrary notwithstanding. The legislature by a two-thirds vote of the members-elect to each house shall provide by law for carrying the provisions of this act into effect.

The report of the engineers was submitted to the commission last April. The matter following is taken from the report.

It was found that the best site for immediate development is about 4 miles above the city of Mobridge, where a plant could be constructed with a 30-ft. head. The cost of the development of a water power plant with this head, on basis of present prices, and exclusive of the transmission system, was estimated at $9,103,000. The cost of the most extended transmission system that appears feasible at this time was estimated at $7,044,000. The total cost of the entire installation thus would be $16,147,000.

However, if the various communities constructed the secondary transmission lines and substations at their own expense the total cost to the state might be reduced to approximately $13,900,000.

It was found that the available market seemed to offer, in 1919, a load of about 30,000,000 kilowatt hours per annum now developed from fuel and for which hydro-electric power might profitably be substituted; and that the market may be expected through the encouragement afforded by cheap power to increase at a rate of about 10 per cent per annum.

Regarding the financing of the development the report states:

> That in view of the present high cost of development and the necessary length of transmission to reach the limited market, the cost of such developments would be too great and the returns to be expected too small to attract private capital.
>
> That even under present conditions, if a rate of growth of the power market of 10 per cent per year can be reasonably anticipated, the state can afford to undertake the development with every prospect of attaining adequate financial returns to maintain and ultimately to liquidate the investment.
>
> That such results can only be attained by conservative financing, intelligent design, economic construction, scientific management and careful operation. These conditions can obtain only through honest and intelligent administration entirely free from political interference. Any departures from these principles would seriously affect the results shown and might involve the state in serious losses.

General Features of the Mobridge Development.—The proposed construction comprises the following features:

A 1,400-ft. dam and spillway, 1,456 ft. long at the foundation, including two abutments.

A power house 384 ft. long.

A lock 60 ft. wide in the clear, 350 ft. between hollow quoins and 121 ft. over all.

About 1,200 ft. of earth dam with concrete core wall.

A small amount of earth embankment at both ends of the structure.

It is proposed to drive steel sheeting, extending from the foundation concrete of each element of the structure into the underlying shale to protect the construction against underflow. The proposed elevation of the crest of the spillway is 1,557 ft. above sea level and the elevation of the top of the earthwork and roadway will be at 1,581 ft. elevation. The maximum depth to shale in the main channel under the power house is about 50 ft.

The dam and spillway proposed is of the OG hollow crest type. The cover and floor will be of reinforced concrete, and the bridge piers and the buttresses which support the cover and the weight of water will be of plain concrete. The proposed spacing of bridge piers for the highway bridge spans is 200 ft., giving six piers on the crest of the spillway which reduces its clear width by 48 ft. at the crest and 30 ft. at the stage of flood capacity. The buttresses supporting the deck or cover of the spillway will be 3 ft. thick and are spaced 12.5 ft. center to center between piers.

Power House and Machinery.—The power house is tentatively designed for ten units, each consisting of a 6,000 hp. single vertical turbine runner, approximately 108 in. in diameter and operating at approximately 78 revolutions per minute. Each turbine will be direct connected to a 5,400 kilo-volt-ampere vertical type generator which will deliver 3-phase, 60-cycle alternating current at 6,600 volts pressure. The step-up transformers for increasing the voltage to 110,000 volts, the transmission voltage that has been selected to transmit the power within the district contemplated, will also be located in the main station. The main switchboard for controlling the various electrical units will be located in the main power station with other auxiliary machinery, such as lightning arresters, switches, transformers, etc.

The estimates of cost are based upon an initial installation of eight of the units, leaving two units to be installed later. Future consideration may show the desirability of installing even fewer units at first.

Transmission System.—The proposed transmission system includes a duplicate 3-phase, 60-cycle, 110,000 volt line from the Mobridge site to Aberdeen, and a single 3-phase loop line with primary substations at Aberdeen, Redfield, Huron, Mitchell, Tripp, Yankton, Sioux Falls, Madison, Brookings, Watertown and Webster. The secondary lines and substations for the initial development would probably be at 33,000 volts or lower.

The estimates are made on the basis of using H-type construction of wooden poles for the line supports with average spans of about 400 ft. and with seven suspension discs per insulation. Each series of insulator discs is to be protected by arcing rods. Two steel ground wires are to be carried on steel bayonets extending above the top of each pole with a steel cable of the same size carried down the pole from the bayonet to a ground plate located in the moist dirt near the bottom of the pole. In order to reduce the chances of interference with telephone and telegraph lines, it is proposed to transpose the main lines at intervals of two to four miles.

In order to decrease the chance of failures on the line, causing interruption to service, it is proposed to make the main trunk feeder from Mobridge to Aberdeen of duplicate 3-phase lines, each consisting of three No. 00000 aluminum cables, steel reinforced, and two ¼ in. double galvanized Siemens-Martin steel strand ground wires. At Aberdeen a special outdoor substation and switching station is provided for the estimate. This substation will be so arranged that either or both of the trunk feeders may furnish current to either or both branches of the loop line in addition to a feeder for Mobridge and two feeders for the territory within the Aberdeen district. At each of the remaining ten primary substations, we have estimated on an outdoor type of substation with switches on either side so that sections of the line may temporarily be cut out for repairs or alterations at any time without interrupting service to any point on the system.

As it is not economical to supply small towns and villages, having a peak load of less than 500 kilowatts, directly from the 110,000-volt line, provision has been made for secondary lines radiating from the eleven main substations or distribution centers to the most important loads in their vicinity.

Detailed Estimated Cost of Development.—The detailed estimate of the cost of the development as proposed at Mobridge are given in the accompanying tables. The quantities have been estimated from preliminary outline plans of the installation suggested. The unit prices used have been taken from tentative quotations obtained from various manufacturers for machinery and equipment based on the plans for the development. Other prices used are the current prices of construction material and actual prices paid on contracts for similar material, machinery and equipment for other projects which the engineers have installed or for which they are preparing plans. The cost estimates in all cases include liberal unit prices for labor, material and machinery. A liberal contingency fund has also been provided, and an estimate of $1,000,000 for interest during construction is included. It is pointed out that many of the items may be changed if the construction is delayed for some time, and that they also will depend somewhat on the manner in which the work is let and the basis on which it is done.

The detailed estimates on basis of construction costs in 1919-20 follow:

ESTIMATED COST OF 110,000 VOLT TRANSMISSION LINE.

	Per mile.
28 wood poles, 8-in. top, 40-ft. BB butt treated, at $20	$ 560.00
5,950 cross arms, two 6-in.—8-lb. channels, at 8 ct.	476.00
28 bayonets, 72-in., at $1.95	54.60
294 insulators, at $2.60	746.40
42 cable clamps, at $2	84.00
42 pairs arcing rods, at 45 ct.	18.90
42 saddles for aluminum cable protection, at 10 ct.	4.20
28 Belcher clamps, "J" type, at 11 ct.	3.08
56 three bolts, at 10 ct.	5.60
10,700 ft. ground wire, ¼-in D. G. Siemens Martin, at $1.75 per 100	187.25
5,380 lb. No. 00000 aluminum cable, steel reinforced, at 30 ct.	1,614.00
Digging holes, 28, at $1.50	42.00
Distributing poles, 28, at $1	28.00
1½ tons distributing wires, at $8	12.00
Distributing insulators, 294, at 5 ct.	14.70
Distributing crossarms and hardware	15.00
Setting poles and assembling, 14, at $15	210.00
Stringing 3 cables and 2 ground wires, 5, at $60	300.00
	$4,374.73
Extra for strains, guys and extra labor, 10 per cent	437.47
	$4,812.20
Right of way	160.00
	$4,972.20
Total per mile of single trunk line	4,972.20
Duplicate trunk line	9,944.40

Transmission Loop.—Estimated on basis of a single line of No. 00 steel reinforced aluminum cable. This estimated cost would be the same as that for the single trunk line above modified for the different size of cable and extra items for strain insulators, guys, labor, etc.

Total per mile for main items	$3,646.73
Strains, guys, extra labor	911.67
Right of way	200.00
Total per mile of loop line	$4,758.40

ESTIMATED COST OF SECONDARY LINES.

	Per mile.
26 wood poles, 8-in. top, 35-ft. BB butt treated, at $15	$ 390.00
26 cross arms, steel, at $4	104.00
78 insulators and pins, at $3.50	273.00
26 tie wires, at $1.10	29.00
26 bayonets, at $1.50	39.00
26 belcher clamps, at 11 ct.	2.86
78 bolts, at 10 ct.	7.80
5,400 ft. ground wire, 3/16-in. D. G. Siemens Martin, at $1.50 per 100 ft.	81.00
2,300 lb. No 0 aluminum cable, steel reinforced, at 30 ct.	690.00
Digging holes, 26, at $1.50	39.00
Distributing materials	35.00
Stringing 3 cables and 1 ground wire, 4, at $60	240.00
Erecting poles and cross arms, 26, at $7	182.00
	$2,112.66
Extra for strains, guys and labor, 20 per cent	422.44
	$2,535.10
Right of way	250.00
	$2,785.10

SUMMARY OF LINE COSTS.

Trunk line, Mobridge to Aberdeen, 100 miles, at $9,944.40	$ 994,440.00
Loop line, Aberdeen to Sioux Falls, 464 miles, at $4,758.40	2,207,900.00
Secondary lines, 600 miles, at $2,785.10	1,647,060.00
	$4,849,400.00

SUMMARY OF SUBSTATION COSTS.

11 primary substations, 33 500 kw., at $27	$ 904,500.00
Secondary substations, 5,000 kw., at $20	100,000.00
	$1,004,500.00
Total	5,853,900.00
Engineering, contingencies and interest during construction	1,190,100.00
	$7,044,000.00

DETAILED ESTIMATE OF COST OF DEVELOPMENT AT MOBRIDGE WITH 30-FT. HEAD.

	Unit price.	Estimated cost.
Spillway—		
Floor, cover, apron, 38,650 cu. yd. reinforced concrete	$ 19.00	$ 735,000
Buttresses, 16,125 cu. yd. concrete	16.00	258,000
Walks, 69.5 cu. yd. reinforced concrete	20.00	1,390
Ladder bars, 14.2 tons 1-in. steel bars	80.00	1,136
Steel sheeting, 1,742.5 tons (driven) 12-in. by 42½-lb.	100.00	174,250
Piling, 236,300 lin. ft. (place) timber, round	.60	142,000
Mat at toe, 23,300 cu. yd. logs, facines, stone, piles	4.00	93,200
Excavation, 153,506 cu. yd. sand and gravel	1.00	153,506
Total		$1,558,982
Power House—		
Roadway foundation, 328 cu. yd. reinforced concrete and asphalt surface	$ 30.00	$ 9,840
Roadway support, 2,750 cu. yd. reinforced concrete	22.00	60,500
Rack platform, 41 cu. yd. feinforced concrete	22.00	903
Walls, 2,890 cu. yd. concrete	22.00	63,600
Aprons, 3,455 cu. yd. concrete	19.00	65,650
Wheel works, 23,482 cu. yd. concrete	22.00	517,000
Piling, 81,100 lin. ft. (place) timber, round	.60	48,700
Trash racks, 412,000 lb. (assembled) steel	.08	32,900
Steel sheeting, 706 tons (driven) 12-in. by 42½ lb.	100.00	70,600
Ceiling windows, 10 (floor construction), each	300.00	3,000
Building, 1,000,000 cu. ft., roof, brick, etc.	.25	250,000
Excavation, 21,700 cu. yd. sand and gravel	1.00	21,700
Fill, 4,470 cu. yd. sand and gravel	.60	2,680
Head gates, 324,000 lb. steel	.12	38,900
Gate machinery, 30, each	1,000.00	30,000
Sluice gates, steel	.....	3,000
8 wheels, 48,000 hp., with governor	7.00	336,000
8 generators, 36,000 kw., with exciter	15.10	544,000
8 transformers, 36,000 kw., 6,600 v. to 110,000 v.	5.78	208,000
Miscellaneous electrical equipment, 36,000 kw., switches, lightning arresters	5.33	192,000
Crane, 1, each	.....	5,000
Machinery, 12½ per cent, installation, total cost	.....	160,000
Total		$2,653,973
Highway—		
Piers in spillway, 3,910 cu. yd. concrete	$ 15.00	$ 58,600
Piling, 12,700 lin. ft. timber, round	.60	7,625
Pratt trusses, 1,126 tons (erected) structural steel	200.00	225,200
Roadway, 2,500 lin. ft. reinforced concrete and asphalt surface	10.00	25,000
Floor of bridge, 830 cu. yd. reinforced concrete and asphalt surface	30.00	24,900
Bascule lift, 100 tons (erected), pat. design, structural steel	300.00	30,000
Floor, 54.6 cu. yd. reinforced concrete and asphalt surface	30.00	1,692
Operating machine	.....	5,000
Total		$ 378,017
Lock—		
Gates, 5,810 sq. ft. steel	$ 15.00	$ 87,200
Lock, 41,600 cu. yd. concrete	15.00	625,000
Piling, 198,000 lin. ft. timber, round	.60	118,800
Steel sheeting, 935 ton (driven) 12-in. by 42½ lb.	100.00	93,500
Excavation, 4,130 cu. yd. sand and gravel	1.00	4,130
Total		$ 928,630
Abutments—		
Abutments, 11,435 cu. yd. concrete	$ 15.00	$ 171,660
Steel sheeting, 183 tons (driven), 12-in. by 42½ lb.	100.00	18,300
Piling, 7,670 lin. ft. timber, round	.60	4,600
Excavation, 10,000 cu. yd. sand, gravel and shale	1.00	10,000
Total		$ 204,560
Railway Spur—		
Track and materials, 15,125 ft. rails, ties, tie plates, ballast, etc.	$ 1.50	$ 22,700
Switches, 7, each	280.00	1,960
Grading, total	.....	5,000
Track laying, total	.....	3,000
Trestle, 500 ft. piling timber	10.00	5,000
Steel sheeting, 100 ton (driven) 12-in. by 42½ lb.	100.00	10,000
Total		$ 48,660
Embankment—		
Core wall, 7,410 cu. yd. concrete	$ 18.00	$ 133,500
Excavation, 4,550 cu. yd. sand and gravel	1.00	4,550
Steel sheeting, 2,738 ton (driven), 12-in. by 42½ lb.	100.00	273,720
Net fill, 700,980 cu. yd. sand and gravel	.60	420,000
Revetment, 1,840 square boulders	10.00	18,400
Total		$ 850,170
River land, 20,000 acres	$ 25.00	500,000
Flowage, cofferdam and pumping		300,000
Total		$7,432,992
Engineering and contingencies and interest during construction		1,670,008
Total cost		$9,103,000

The conclusions of the engineers regarding the estimates are given in the report as follows:

An examination of our estimates may lead those unfamiliar with the contingencies of hydraulic construction to conclude that the unit prices used are unduly large even under existing conditions. We have endeavored to make a sufficiently liberal estimate so that by good management and with reasonably favorable conditions the actual cost will not exceed the estimates we have made. Our personal experience in the design and construction of hydraulic plants has taught us that there are many contingencies, which may arise in such construction, that we cannot foresee or provide for except by the use of liberal unit prices. In an estimate of this kind there are many items and expenses which cannot easily be tabulated when only outline plans are used, but which must be covered by a liberal estimate. It should also be noted that the problem of making an estimate at this time when prices are rapidly fluctuating and may increase or decrease materially in the near future, is a serious undertaking and cannot be safely done except by the use of liberal unit cost estimates. It is obvious that a continued rise in the cost of labor, material and machinery in the next year or so may render even the liberal prices we have used inadequate for the construction of the proposed development. At the present time prices are in most cases at least 67 per cent above the prices of 1915, and in some cases they have more than doubled. It is also obvious that whenever the country returns to a sound business basis, a reduction in present prices is to be expected. We believe, however, that nothing short of a serious financial panic will return prices to their pre-war basis. The rise in the cost of labor will, at least to a considerable extent, be permanent and a consequent rise in the cost of material, machinery and other equipment into which the cost of labor enters to a large degree will necessarily be greater than those which obtained under pre-war conditions, although it is hardly probable that they will remain at the present inflated values.

While any estimate of the decrease in cost which will accompany the return of the country to a stable business condition must be uncertain, we confidently expect an ultimate decrease of about 25 per cent in the present costs, though when this return will occur is uncertain. It can hardly be expected for at least one or two years. All these matters have been carefully considered in making our estimates, which we believe are adequate to cover actual costs at the present time.

In concluding their report the engineers state:

It should be noted that the estimated cost of the development on the basis of construction costs in 1919-20 is approximately 67 per cent greater than it would have been in 1914; that the present financial situation is unstable and undoubtedly inflated; that the present prices that have heretofore been increasing may be at a peak; and that the present situation in regard to labor, materials and capital is not favorable to such enterprises. The advisability of undertaking the development at this time becomes a serious question, the final decision of which must be left to your honorable body and to the Legislature, who are responsible to the electors of the state.

Niter Cakes as a Mosquito Larvicide

Niter cake, according to the April issue of Public Works of the Navy, has proved very efficacious in the destruction of mosquitoes and flies at the Philadelphia Navy Yard. Niter cake ($NaHSO_4 + H_2SO_4$) also known as sodium bisulphate, sodium (acid) sulphate, Edis compound, and by other names, is the solid fused salt remaining from the manufacture of nitric acid, and small amounts are produced at sulphuric acid plants. It is sold in lumps weighing from 12 to 30 lb. and the cost is about $85 per ton. It is best shipped in bulk, and will weigh about 50 tons per box car. Handling should always be done with a shovel, and it should not be allowed to come in contact with the skin or clothing, as it is destructive, though not toxic. It is used in solutions of from 20 to 50 per cent strength, depending on the district to be treated.

The following table, giving results of experiments with niter cake carried out by Dr. Fairfax Irwin, sanitation officer, 4th Naval District, is reprinted from Public Works of the Navy:

Size of pond.	Depth, in inches.	Pounds of niter cake required.	Size of pond.	Depth, in inches.	Pounds of niter cake required.
20 by 20 ft......	3	8	80 by 80 ft......	3	230
	6	10		6	475
	11	20		11	840
	18	30		18	1,360
	24	40		24	1,820
40 by 40 ft......	3	20	100 by 100 ft.....	3	480
	6	40		6	720
	11	100		11	1,320
	18	150		18	.....
	24	220		24	.....
60 by 60 ft......	3	120			
	6	250			
	11	490			
	18	800			
	24	1,000			

Experiments at the New Jersey Agricultural Experiment Station in April, 1918, in the use of niter cake as a mosquito larvicide, resulted in the following conclusions:

Culex pipiens may be taken as a type of the fresh-water species, Aedes sollicitans of the salt-marsh species. It appears that 1 gram of niter cake to 1,000 c.c. of water is barely sufficient to destroy the larvae of Culex pipiens in two days' time, but that stronger solutions (1 gram of niter cake to 100 c.c. of water) destroy the species readily and remain effective for 24 days or longer. It also appears that 6 grams of niter cake to 1,000 c.c. of water testing 7 per cent salinity is necessary to destroy the larvae of Aedes sollicitans, and that three days are required to accomplish this result. The bearing of these results upon the practical use of niter cake as a larvicide needs elucidation. In view of the fact that a diminution in the strength of the solution results in its loss of efficiency, niter cake should not be used as a larvicide except in pools and bodies of water that have no outlet. In view of the cost of distributing the material, it would seem unwise to use minimum strength. Enough should be put in to insure not only prompt destruction of the larvae but a reasonable continuance of that effect. Considerable time is required for dissolving the cake, and its distribution through the water is relatively slow. Throwing the material into the pool in lumps, or even in ground form, is likely to result in unsatisfactory results, because of the slowness with which it will dissolve and distribute itself in solution. These difficulties are great and need to be overcome before its use can be considered very practical.

Method and Cost of Constructing 1 1/4 Mile Concrete Flume with Cement Gun

By R. G. CLIFFORD,

Chief Engineer, Natomas Company of California.

In order to conduct a body of water amounting to 160 c.f.s. across the low land between the river and the long ridge of District 1000, it was necessary to convey the water in either a lined ditch with banks having a maximum height of 11 ft. and averaging nearly 8 ft. or to use some form of flume construction.

On account of the high cost of transporting materials to this point it was finally decided to utilize the cement-gun method in the construction of a concrete flume 10 ft. wide inside and about 5 ft. 9 in. deep. It was necessary, first of all, to construct a moderate sized fill for this flume. The fill was made 20 ft. wide and was thoroughly compacted by allowing the winter rains to settle it and then giving it a thorough rolling. The flume was started in the latter part of January, 1919, and was completed on May 17, 1919. The work was interfered with to a considerable extent by a fairly heavy rainfall, particularly in the month of February. The cost of work of this character increases rapidly with wet weather, owing not only to lost time but difficulty of hauling materials through the adobe land and delays caused by trying to put wet sand through the cement gun and the poor pressure conditions caused by the damp weather.

Sectional Forms for Flume.

Cement Gun Equipment Used on Work.

It was aimed to use a mixture of 1 part of cement to 4 parts of sand, but on account of the large percentage of rebound from the sand on the wooden forms used on the outside, the actual mixture, figured from the amount of cement used, was less than 7 part of cement to 3 of sand.

The sand used for this work was of the very best, being Yuba River sand from the deposits at Marysville, and cost $1.45 per yard on board the cars at the nearest railway station 8 miles away and across the river. The sand was unloaded by hand, carried by a conveyor onto a barge, was towed to a landing adjacent to the work, reloaded into wagons by hand and hauled an average of ¾ mile to the work. During rainy and foggy weather it was necessary to dry as much sand as possible with a night shift, but even then a great deal of trouble was had putting the material through the hose.

The cost data given below include every item of expense connected with the work, including a share of the superintendent's and timekeeper's time and general automobile expenses, but does not include overhead charges for the camp itself. No depreciation has been included for the $6,000 worth of equipment used, which would add 12 ct. per foot to the total cost given below, bringing the grand total up to $7.21 per lineal foot.

Shooting Walls and Floors.

The method of shooting the flume which was finally found to be the most satisfactory, was to first shoot the lower corners between the floor and the walls, then to shoot the walls, which are 2½ in. thick and have a reinforcement composed of Clinton electrically welded mesh with the vertical wiring of No. 6 gage 4 in. apart made up in straight sheets 12 ft. 6 in. long. The mesh was carefully held 1 in. from the form with a slotted bar, while patches of concrete were shot against the form to hold it in place before the main shooting began. After the walls were completed, including the coping (the horizontal precast concrete struts 4 in by 4 in. in diameter having previously been set in place), the rebound composed mainly of sand was all shoveled away from the bottom and wasted, and after rolling out the 5 in. by 9 in. No. 10 No. 12 mesh along the bottom, the floor was shot. One man and a helper then came along with finishing screed, smoothing the walls, but not too close behind the gun work, as it is necessary for the cement to take its initial set or there is danger of the unsupported concrete falling down.

Completed Flume 1¼ Miles in Length.

The flume was filled one-half full of water and the sides kept wet fairly close behind the gun work to prevent too rapid drying out. When water was first run through the flume, hair cracks developed at intervals of about 4 to 5 ft. through which a negligible leakage was apparent. After 2 or 3 days, however, the concrete swelled sufficiently so that there was absolutely no sign of moisture on the outside.

No contraction joints were used, although there was one curve of about 45° and one crossing 45 ft. long over a drainage canal where an ordinary concrete flume of the same interior dimension, but with 6 in. walls well reinforced, had previously been poured.

The equipment used on this work consisted of an N-2 cement gun, operated by a 12 in. by 8 ¾ in. by 12 in. straight line compressor, mounted on trucks but operated with a 40 hp. electric motor instead of the regular hot-head drive furnished with a compressor. This necessitated building power lines alongside of the flume and moving the transformers with each move of the compressor. A small (typhoon) gas engine handled the water for the cement gun as well as for sprinkling.

The costs for the 5,438 ft. of flume were as follows:

	Total.	Per lin. ft.
Labor:		
Hauling material	$ 4,208.64	$0.79
Form work	1,629.66	0.30
Placing and bending reinforcing	963.43	0.18
Making struts	517.06	0.10
Gun work	8,503.01	1.60
Drying sand	226.14	0.04
Sub-grade trimming	809.12	0.15
Installing, moving and repairs	1,964.76	0.37
Total	$18,821.82	$3.53
Material:		
Forms	$ 862.44	$0.16
Cement	7,417.36	1.39
Sand	3,549.72	0.66
Reinforcement	3,022.00	0.57
Repairs	431.36	0.08
Incidental supplies	1,059.79	0.20
Total	$16,342.67	$3.06
Auto charges, stock rental and feed	2,625.10	0.49
Power	710.41	0.13
Grand total	$38,500.0	$7.21

Consumption of Water at Locomotive Terminals

Interesting statistics relating to the use of water at engine terminals are given by Mr. F. D. Yeaton in The Employes' Magazine of the Chicago, Milwaukee & St. Paul R. R. in an article urging water waste reduction.

This company purchased an average of 538,000 gal. of water per day at Minneapolis and an average of 2,730,000 gal. per day at Milwaukee during 1918. The water which the company purchased at Minneapolis during 1918 cost $15,710. The water which the company purchased at Milwaukee during the same period cost $76,470. If the company could reduce the water bills at Minneapolis and Milwaukee 10 per cent by means of a water waste campaign, the annual saving would amount to $9,218, which would be well worth the effort.

In planning a water waste conservation campaign it would be a good policy to consider the larger engine terminals first. The following engine terminals use approximately the amount of water shown and present an opportunity for considerable saving:

Terminal.	Approximate gal per day.
Milwaukee	2,700,000
Minneapolis	1,000,000
Savanna	775,000
Bensonville	760,000
Dubuque	725,000
Perry	450,000
Aberdeen	425,000
Chicago, Western Ave.	300,000
Chicago, Galewood	300,000
Montevideo	300,000
La Crosse	300,000
Sioux City	300,000
North McGregor	245,000
Coburg	240,000
Mason City	225,000
Atkins	200,000
Manilla	200,000
Ottumwa Junction	200,000
Portage	200,000
Green Bay	200,000
Madison	200,000
Wabasha	200,000
Council Bluffs	200,000
Milbank	150,000
Laredo	125,000
Sanborn	100,000
Jackson	100,000
Channing	100,000

There are 28 engine terminals, located on the lines east, that consume an average of 100,000 gal. or more per day. The total average gallons of water used per day at these 28 terminals amounts to 11,220,000. Based on an average cost of 5 ct. per thousand gallons, which is probably rather low, the total daily cost of water at these terminals is $561, which amounts to $204,765 per year. If a saving of 10 per cent can be made at these 28 terminals, it would amount to $20,476 per year. This is the interest on $341,366 at 6 per cent.

Supervision and Laboratory Control in Purification Plant Operation*

By LEWIS I. BIRDSALL.

Superintendent of Filtration, Waterworks Department, Minneapolis, Minn.

Eternal vigilance is the price of pure water. Every water purification plant from the smallest liquid chlorine installation to the largest and most complete filtration plant should be operated under competent supervision and careful laboratory control.

The cheapness and demonstrated effectiveness of liquid chlorine as a sterilizing agent for water supplies have induced many water works officials in Minnesota, as elsewhere in the United States, to rely on chlorine as the sole means of water purification. Such an installation may, however, merely afford a false sense of security. Failure to keep up the chlorine treatment continuously and in amount sufficient for sterilization of the water may mean a typhoid fever epidemic in the community. This danger is greatest among the smaller water works plants where one man is frequently responsible for the operation of the pumps and the chlorine machine. The result is that the pumps get most of his attention and the chlorine machine is neglected.

There are many water works plants, and among them some that are not small plants, that rely for chlorine sterilization on one machine only, so that when it is necessary to change chlorine cylinders or to make necessary repairs, the chlorine feed has to be discontinued. Too much stress cannot be placed on the necessity of duplicate installations of liquid chlorine machines wherever used, so that when one machine is taken out of service the other may be put in service immediately and continuous treatment be obtained. There should also be kept on hand a supply of extra parts for the chlorine machines, so that ordinary repairs may be quickly made in case of emergency. Our state boards of health should require duplicate installations of liquid chlorine machines.

Chlorine cylinders that are in service should be placed on scales and a record be kept of the weight of the cylinders every hour, not only as a check on the manometer gage of the chlorine machine but also to accustom the operators of plant to inspect the machines frequently to see that they are working properly. The scales prevent chlorine cylinders from going empty unexpectedly and the recorded weights serve as a check on the faithfulness of the operator provided that the amount of water treated each hour is accurately determined.

But how shall we know that we are adding the proper amount of chlorine to the water in order to obtain sterilization at all times? There is no general rule for the amount of chlorine to use. The suspended matter, dissolved organic matter and the bacterial content of surface waters, especially river waters, are constantly changing. The amount of chlorine necessary for sterilization of the water is influenced by all three of these factors. A filtered water or a fairly clear and pure water requires less chlorine than does a turbid water or one containing a large amount of dissolved organic matter. Whereas a treatment of 0.3 part per million (2½ lb. of chlorine per 1,000,000 gal.) may be satisfactory in the first case, a much larger dose is required in the latter instance. Residual tastes and odors must be considered in the treatment of some unfiltered waters. A slight variation in the amount of chlorine added may mean either under-treatment and lack of sterilization or over-treatment and complaints from the water consumers. Sterilization takes place less readily in cold water than it does in warm water, and so it is necessary to allow a longer period for the reaction in winter than in summer. Experience has shown that free chlorine disappears much more rapidly from the treated water when the water is passed through iron pipes than when it goes through a concrete conduit.

It is evident that in order to regulate the chlorine treatment properly there must be laboratory control. The test for free chlorine in the treated water, and the determinations of the number of bacteria and the presence or absence of B. coli in the untreated and treated waters offer such control tests. Because of the lag of 48 hours in the results of the bacteriological tests made necessary by the incubation of the inoculated media, it is advisable in most plants to add sufficient chlorine to the water to produce a slight residual free chlorine content of approximately 0.05 part per million. Some waters, as stated above, do not permit of over-treatment, but such waters are comparatively few, and when they occur, the treatment requires very careful supervision. In the majority of cases, therefore, the chemical test for free chlorine becomes the one on which we rely for sudden changes in the chlorine treatment, and the test should be made several times each day. The bacteriological tests indicate the results of the treatment and demonstrate the purity of the treated water. They should be made daily on both the untreated and treated waters.

Chlorine is comparatively cheap, much cheaper than human lives, and therefore it is much more desirable to over-treat a water supply with chlorine than to under-treat it, if reliance for purification is placed on chlorine alone. A chlorine taste in the water, even though it may be unpleasant, is less harmful to the water consumers than a tasteless water that contains typhoid bacilli.

The laboratory tests necessary for the control of a filter plant are more comprehensive and elaborate than those described for a chlorine plant. Turbidity, color, alkalinity and the bacterial content of the untreated water usually determine the amount of chemical necessary for proper coagulation of the water before it goes to the filters. The same tests on samples of the water as it goes to the filters from the coagulation basins determine the efficiency of the pre-treatment. A properly coagulated and filtered water should have no turbidity and a color of 10 parts per million or less. The bacterial content of the filtered and sterilized water should be as near zero as possible and B. coli should be absent in 50 cc. amounts of the water.

An odor in the untreated water may be caused by algae and a microscopical examination of the water will disclose the offending organism. Odors from manufacturing wastes are sometimes more difficult to eliminate from the water than are those from micro-organisms. Tests for odor should be made on both the untreated and the filtered water.

The alkalinity test demonstrates the presence of carbonates and bicarbonates in the untreated water, and whether or not they are sufficient in amount to decompose the coagulant to be added. The filtered water should at all times have residual alkalinity as a safeguard against the presence of undecomposed coagulant.

Free carbonic acid frequently occurs in surface waters. A determination of the amount present should be made where lime is used in conjunction with iron sulphate as coagulant. The amount of free carbonic acid in the filtered water should be determined because of the part it plays in the corrosion of exposed iron surfaces in distribution pipes.

The test for residual chlorine is essential, as already described above.

Total hardness tests are made at intervals for the purpose of record. Complaints regarding the hardness of the water supply are more easily answered if data are at hand to show that the filtered water is no harder than the untreated water and that the hardness of the water is greater at certain times of the year due to natural causes.

Complete sanitary chemical and mineral analyses of the untreated and filtered waters are made each month in the larger filtration plants for the purpose of record. These data are not necessarily essential for the proper operation of the plant, but they are of value for reference.

Analyses of the chemicals used for water purification are valuable and there should be frequent tests of the chemical solutions that are added to the water.

The most essential laboratory tests for the proper control of a filtration plant are those for turbidity, color, alkalinity, residual chlorine, number of bacteria per cubic centimeter and B. coli. The data obtained from these tests will enable the operator to handle his plant economically and efficiently. He will at all times have the satisfaction of knowing the quality of the untreated water and the degree of purification obtained by the plant. The health of a community is the final test by which the purity of a water supply is judged, but the operator of a water purification plant who knows each and every day that the water he is supplying is of the highest purity has nothing to fear from health statistics.

A water softening plant requires certain special laboratory tests in addition to total hardness, alkalinity and free carbonic acid determinations. Only under laboratory control can a softening plant be properly operated.

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*From a paper read before the Minnesota Section of the American Waterworks Association.

It seems almost inconceivable that anyone should attempt to operate a water purification plant without daily laboratory control tests, but experience has shown that many plants are so operated. An occasional bacteriological analysis of a water supply, whether monthly or weekly, has little significance. It merely shows the condition of the water at the time the sample was taken. The splendid work of the Sanitary Division of the Minnesota State Board of Health is tending to raise the standard of water purification plants in Minnesota and to demonstrate that the saving of human lives rather than dollars is the high ideal we should have constantly before us.

Texas has set an example to other states by organizing a short course for water works superintendents and purification plant operators at the University of Texas. The local sections of the American Water Works Association can do no greater good for their communities than by stimulating interest in the organization of similar courses of instruction in their state universities and then urging the water works men to attend these courses. The farmers long ago realized the value of short courses at the State University and now attend them annually. Why cannot the universities do for the water works men what they have done for the farmer? The possibilities for education in this new field are unlimited.

Many small water purification plants are unable to pay the salary of a competent analyst. Such plants no doubt have some employee who could learn to perform some of the more simple routine tests, such as those for turbidity, color, alkalinity and free chlorine, provided the necessary chemical solutions are prepared for him. The bacteriological tests are somewhat more difficult, but even these can be performed by such an employe if he shows an aptitude for the work and provided the necessary media can be furnished. A competent water purification expert could no doubt be employed by a number of such plants at a comparatively small expense to train the operator, interpret the laboratory results thus obtained, furnish the necessary chemical solutions and bacteriological media, supervise the general operation of the plant, and visit the plant periodically. Such an arrangement obtains in some sections of the United States and has been found to work very satisfactorily.

A water purification plant that is operated without laboratory control is merely furnishing a false sense of security to the community. The same plant when operated under laboratory control and competent supervision can and should yield a safe and pure water at all times.

Leakage from Lead-Hydro-Tite Joints

Results of tests for leakage of a new style of pipe joint were given by Mr. Fred O. Stevens, Superintendent, Water Department of Weymouth, Mass., in a paper presented March 10 before the New Egland Waterworks Association.

In the summer of 1917 the Weymouth waterworks laid 3,400 ft. of 8-in. pipe from which no services were taken until the following season. The joints were of Lead-Hydro-Tite. In the test the new gate controlling this line was by-passed with a ⅝-in. Empire meter registering 99 per cent on 1/32 in. opening at 70 lb. gage pressure. For the final measurements the flow was too small for accurate measurement by meter, and a force pump was used pumping from a pail, into which water was fed by a standard gallon measure. The results as to leakage per linear foot of joint are shown in the following table:

TESTS FOR LEAKAGE FROM LEAD-HYDRO-TITE JOINTS IDLEWELL EXTENSION, NORTH WEYMOUTH, MASS.

Date.	Section.	No. of joints.	Gals. per minute.	Gals. per 24 hrs. per lin. ft. of joint.	
1917.					
July 26	1	75	3.375	25.900	New joints.
*Aug. 8	1	75	.150	1.151	
Aug. 20	2	180	.322	1.030	Sec. 1 plus 105 new joints.
Aug. 25	2	180	.375	1.200	
Sept. 29	2	180	.217	.695	
Nov. 2	1	75	.041	.314	
Nov. 2	2	180	.098	.314	
Nov. 2	3	250	.495	1.141	Sec. 2 plus 70 new joints .
Nov. 2	4	335	3.500	6.000	Sec. 3 plus 85 new joints or entire extension.
1918.					
*June 1	4	335	.150	.255	

Average pressure, 70 lbs.

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*By pump and gallon measure.

Special Adaption of Imhoff Tanks for Sewage Treatment at Miami Camps

Sedimentation tanks of a modified Imhoff pattern are used for the treatment of sewage from the construction camps of the Miami Conservancy District, Dayton, O. An interesting description of the tank and the sewer systems at these camps is given in the May Miami Conservancy Bulletin, from which the matter following is abstracted.

The application of a system of sewage treatment to the needs of the conservancy camps naturally required special adaptation. The camps are small, the two largest were built to accommodate a total maximum camp population of about 500. For conservancy use they would be operated about four years, after which the whole camp plant would have to be disposed of. The sites are all several miles from the nearest town or city, but in all cases except one are near railway or electric railway lines. Under such circumstances it was considered best to so design the camps that they could become permanent villages after the conservancy work was done. The buildings are inexpensive, 1 or 2-story structures of the summer cottage type, with water, electric and sewerage service provided.

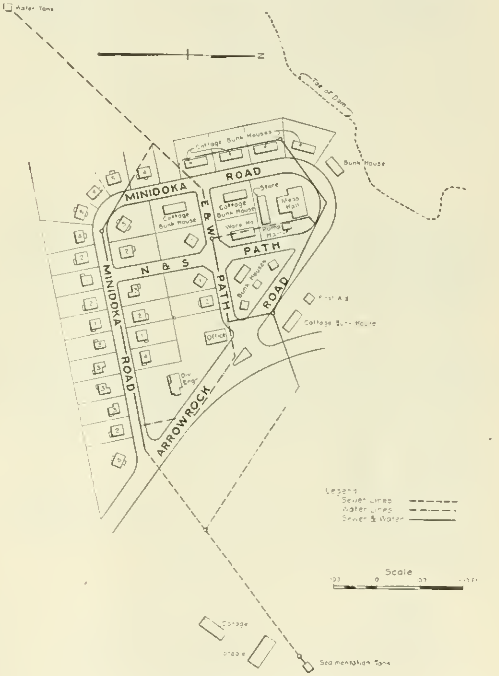

Fig. 1—Water and Sewer Pipe Layout at Germantown Camp of Miami Conservancy District.

This is the most compact camp layout. The camp accommodates about 300 people. Water and sewer pipes in the same trench are indicated by solid lines. Sewer pipe lines by dotted lines. Water pipes by dot-and-dash lines. All houses are provided with electric, water and sewerage facilities.

The sewerage service in such a case must be simple and inexpensive. It must be simple because after the conservancy work is done, skilled attendance it out of the question. It must be inexpensive , obviously, both for conservancy use and for later recoupment of cost in the sale of the cottages.

At the indoor end, the plumbing is of modern standard design with open plumbing, and sufficient to allow for free use of the village water and proper disposal of all household waste. Connection to the pipe lines in the streets is by 4-in. standard sewer pipe. All equipment, of course, passed the Ohio Board of Health inspection.

The street pipes are 6 or 8 in. in size, and take only the house sewage, storm water from the streets being excluded.

To include the latter would have required so large pipes as to make the cost prohibitve. The lines were so located that wherever possible the same trenches would serve both water and sewer pipes, thus saving expense. The sewers were laid on a minimum grade of about 9½ in. in 100 ft.

For sewage treatment a standard pattern of Imhoff tank would cost too much, largely on account of the depth necessary, approximating 30 ft. Rock occurring near the ground surface, this would require expensive excavation, since the tanks must be below street sewer level, in order to receive the sewage by gravity flow. It was for this reason that the design indicated in Figs. 2 and 3, was adopted. By locating the greater part of the sludge chamber, between the two sedimentation chambers, instead of below them, a great saving in depth was obtained, while at the same time the sludge decomposition was completely separated from the fresh liquid sewage, as the best results require.

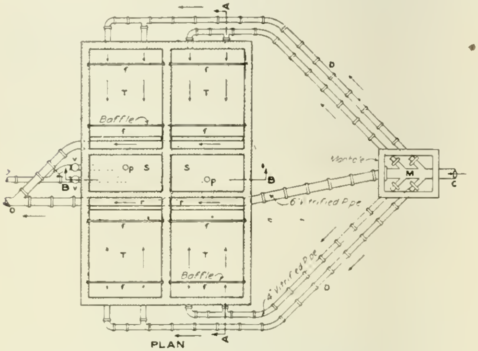

Fig. 2—Plan of Sedimentation Tank.

The tank used at the conservancy camps consist of three rectangular concrete chambers side by side. The fresh liquid, bearing the solids, mostly in a finely divided state, flows through the two out-side chambers, "TT," Fig. 3, in a very slow stream, the chambers being very large in proportion to the pipes which bring the sewage. The bottom of these side chambers is sloping. The solids sink to the bottom and slide on down the slope through a wide slot into the central chamber "SS," where they collect and remain in a mass at the bottom.

The mixed ripe sludge and water is drawn off periodically through pipes and valves (pp. and vv. in Figs. 2 and 3) opening through the bottom of the sludge chamber, the water constituting 75 to 85 per cent of the mass.

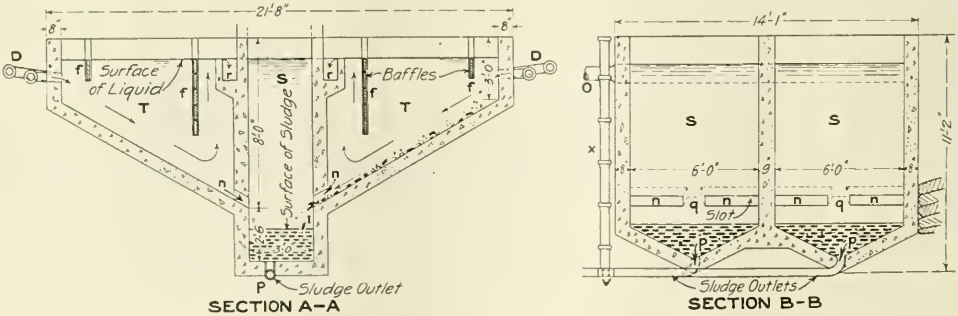

Fig. 3—Sections of Sedimentation Tanks Installed at Construction Camps of Miami Conservancy District.

The liquid sewage in the side chambers of the conservancy sedimentation tanks, "TT," after the removal of the solid particles as described, flows on, passing under the "scum boards" "ff" and then over the side wall of the trough "rr" into that trough, thence along the trough to the outlet pipe "O."

It is interesting in this connection to compare the conservancy tanks with the sedimentation tanks at Orange, Calif. These were orginally the old-fashioned septic tanks, and were a nuisance on account of the odor. They were of concrete and were transformed to a modified Imhoff pattern by building inside of them redwood partitions and sloping floors. They were not deepened in the process, however, the depth from the bottom to the surface of the liquid after the change being only 7 ft. 9 in., as against three or more times that dimension in the standard Imhoff design.

Nevertheless, the transformation greatly improved the conditions, the sludge after the change being "typical dark-brown Imhoff tank sludge" drying readily after its removal from the tanks. The conservancy tanks show a depth below the surface of the liquid of 9 ft., 6 in., as against the 7 ft. 9 in. at Orange, and after being in use more than a year, create no perceptible odor even in the near neighborhood.

The effluent from the various conservancy camp tanks is discharged into creeks and rivers.

Flume Carried on Bridge of 125 ft. Cantilever Spans

The Garfield Canal of the Rio Grande Project of the U. S. Reclamation Service is carried across the Rio Grande River by a flume bridge of rather unusual type. The novelty of the structure lies in the application of the cantilever principle to spans of short length. The bridge is 800 ft. long and consists of four cantilever spans of 125 ft. and 5 suspended spans of 52 ft., the piers being approximately 93 ft. 6 in. on centers. There is nothing unusual about the general type of structure, exactly similar arrangements having been frequently employed. It is, however, generally considered that this type of construction is not economical for spans of less than the upper limit of simple span trusses. The bridge is described by D. C. McConaughty, Assistant Engineer, U. S. Reclamation Service, in the April Reclamation Record.

The bridge in question was designed late in 1916 at a time when current prices made a steel overhead crossing considerably cheaper than a concrete siphon. It supports twin No. 156 galvanized steel flumes carrying a total discharge of 350 cu. ft. per second. A single flume of larger size would have reduced the cost considerably but was out of the question on account of the limited clearance available above high water.

Estimates were prepared for the usual type of structure, i. e., two simple span trusses with the inside edges of the flumes supported by floor beams, but on account of the length of beam necessary, the amount of metal required for the floor beams was considerably more than was required for an extra truss, and it was decided to use three trusses per span.

In an attempt to reduce the weight still further it was then decided to prepare an estimate for the cantilever type.

This estimate showed a saving of approximately 12 per cent as compared with the simple truss spans. The objections usually made against a cantilever are its lack of rigidity and excessive deflection, neither of which is especially important in the case of a flume bridge where the load is practically a uniform dead load. The three-truss cantilever type was therefore adopted.

In the advertisement, bids on alternate designs were requested, the only limitation made being the size of the flume and the invert grade. Proposals were received from eight bidders, two of the bidders submitting bids on simple trusses as an alternate design, and one on a cantilever type with a slightly different arrangement of spans. The three lowest bids were on the cantilever type of structure.

A Page from Recent Waterworks Reports

Cost of Meter Repairs at Milwaukee, Wis.—The following table reprinted from the 1919 report of H. P. Bohmann, Superintendent of Waterworks of Milwaukee, shows the cost of operation of the Meter Division, and the cost of meter repairs for the year ending Dec. 31, 1919:

Item.	No. of meters.	Total cost.	Per meter ⅝ to 12 in.
Repairs—Material and labor	18,214	$33,856	$1.85
Chargeable to consumer	3,985	18,923	4.74
Chargeable to department	14,229	14,932	1.04
Average cost of repairs—based on all meters in service	65,769	33,856	.51
Net cost to department—based on all meters in service	65,769	18,923	.28
Net cost to department—based on meters repaired	18,214	18,923	1.03
Total cost of operation for all meters in service	65,769	62,676	.95
Less revenue received		28,505	....
Net cost of operation for total number of meters in service	65,769	34,170	.51

Difficult Water Main Construction.—Unusual difficulties were encountered in laying a 12-in. main to replace old 8-in. pipe in South Canal St., Milwaukee, Wis. The new line was laid about 14 ft. distant from the old one. About 3 ft. below the surface an old abandoned railroad track several hundred feet in length was found, it having been left in place when the street was filled from time to time. The oak ties were still in sound condition and the rails spiked to the ties. The rails had to be removed and the ties chopped through by hand before the contractor could proceed to lay the pipe. Piles, timbers and waste material from a former stone yard were encountered in the line of trench besides a great deal of water, making it one of the most disagreeable jobs of pipe laying ever undertaken in the city.

Concord, N. H., Water Works Earns $2,378,775 in 47 Years.—The water works of Concord, N. H., on Jan 1, 1920, had cost $1,113,053. Of this total $148,000 was for water rights; $104,000 for land; $35,546 for dam, gate house and appurtenances; $29,818 for conduit and gate houses; $182,000 for mains; $402,000 for distribution system, $68,006 for service pipe; $45,000 for reservoirs; $29,750 for pumping station, and $20,706 for pumping machinery. The water works were constructed in 1872, and the total receipts from them for 47 years has been $2,378,775, according to the 1919 report of P. R. Sanders, Superintendent.

Percentage of Sizes of Water Mains in 18 Cities.—An interesting comparison of the sizes of pipes in the distribution systems of several cities in the United States is given by R. C. P. Coggeshall, Superintendent of Waterworks of New Bedford, Mass., in his report for the year ending Dec. 31, 1919. The table, based on 1917 reports, shows that 0.3 per cent of the system of Cincinnati, O., and 0.1 per cent of that of Buffalo, N. Y., was 60-in. pipe; 0.2 per cent of the system of Springfield, Mass., was 54 in.; 3.3 per cent of the system of Cambridge, Mass., was 40 in., 0.5 per cent of the system of Albany, N. Y., was 20 in., and 2.9 per cent of that of Woonsocket, R. I., was 14 in. Percentages of 3 in. and 2 in. were as follows:

	3 in.	2 in.
New Bedford, Mass.	0.1	0.4
Springfield, Mass	...	1.7
Holyoke, Mass.	...	0.2
Albany, N. Y.	0.1	...
Detroit, Mich.	0.7	0.1

The percentages of other sizes of mains were as follows:

	48 in.	42 in.	36 in.	30 in.	24 in.	20 in.	16 in.	12 in.	10 in.	8 in.	6 in.	4 in.
New Bedford, Mass. (1918 report)	4.7	...	6.7	4.5	1.7	1.2	5.3	5.6	7.9	20.9	35.6	5.4
Cambridge, Mass.	...	...	. .	0.2	1.9	4.0	1.3	11.3	4.8	11.5	49.7	12.0
Springfield, Mass.	...	5.4	2.7	4.5	5.3	0.7	4.4	6.1	3.8	21.4	38.3	5.5
Lowell, Mass.	...	...	...	0.5	1.1	1.0	3.7	9.4	4.1	19.5	56.5	4.2
Holyoke, Mass.	...	...	...	...	3.5	14.6	7.3	8.9	10.2	13.2	30.1	12.0
Taunton, Mass. (exclud. force main)	...	...	...	...	...	3.1	4.6	9.1	0.1	24.5	50.1	8.5
Woonsocket, R. I.	...	...	...	...	...	4.7	...	11.3	1.9	22.1	43.7	13.4
Albany, N. Y.	0.9	...	0.3	2.7	3.7	3.0	3.0	18.9	1.8	21.7	36.0	7.4
Providence, R. I.	...	1.2	4.5	2.8	2.1	0.5	2.7	7.8	0.7	15.5	62.1	0.0
*Detroit, Mich.	2.5	2.6	0.5	0.9	2.3	0.0	1.9	4.3	4.0	19.7	47.5	13.0
*Cincinnati, Ohio	0.4	0.3	2.56	0.7	1.68	...	3.6	3.95	†	‡	44.1	21.6
*Louisville, Ky.	2.0	...	1.6	2.5	...	...	...	...	†	‡	55.4	14.9
*Cleveland, Ohio	0.7	...	1.7	3.2	20.0	0.6	...	...	†	‡	55.4	4.5
*Milwaukee, Wis.	...	0.6	2.4	2.1	0.39	1.5	...	..	†	‡	70.5	0.7
*Buffalo, N. Y.	1.3	...	4.4	...	...	2.6	9.7	...	†	‡	59.2	6.7
*Toronto, Ont.	...	0.1	2.8	0.4	1.4	...	0.7	17.3	†	‡	71.2	2.7
*St. Louis, Mo.	...	...	4.4	3.4	...	8.9	...	18.0	†	‡	61.1	.21
*Columbus, Ohio	...	...	1.1	...	...	...	...	1.1	...	22.1	51.3	6.9

*Taken from report of Detroit water works. †Average 7 cities 3.6. ‡Average 7 cities 6.5.

Distribution of Water Consumption in Milwaukee, Wis.—The total water consumption of Milwaukee, Wis., for 1919 was 21,460,913,450 gal., according to the annual report of H. P. Bohmann, Superintendent of Waterworks. Of this total 78.41 per cent was metered; 5.41 per cent estimated flat rate consumption; 0.67 per cent unmetered free use; 2.43 per cent due to underregistration of meter (estimated at 3 per cent of water passed through meters): and 13.08 per cent was "unaccounted for." The distribution of consumption was as follows:

	Gallons per capita.	Percentage of net pumpage.
Municipal use	12.33	10.48
Industrial use	45.79	38.95
Commercial use	40.45	34.39
Under-registration of meters	2.85	2.43
Departmental free use	.78	.67
"Unaccounted for"	15.39	13.08
Totals	117.59	100.00

Vegetable Accumulation on Reservoir Bottom and Slopes.—In his 1919 report R. C. P. Coggeshall, Superintendent of Waterworks of New Bedford, Mass., states that commencing May 19, High Hill Reservoir was gradually lowered for the purpose of inspection. The concrete bottom and slopes of the south basin was exposed from May 28 to May 30 inclusive. It was found covered with a vegetable deposit of 14 years' accumulation, averaging 2 in. and upwards in depth. This deposit was removed in thick liquid form by passing same through drain pipes which pass through east gatehouse and deliver at the foot of the eastern embankment slope.

39 Gal. Per Capita Water Consumption.—The daily per capita water consumption at Dover, N. H., is among the very lowest in this country. According to the 1919 report of Henry S. Perry, Superintendent, the daily consumption for that year was but 38.9 gal. per inhabitant. The city is 81 per cent metered, and 83 per cent of the income is from metered water.

Flow of Water for Various Sized Orifices and Pressures.—The accompanying table from the 1919 report of Henry E. Perry, Superintendent of Water Works of Dover, N. H., shows how easily water can be wasted:

Diameter of orifice in fractions of an inch.	Pound pressure per square in. at orifice: 50 lb. Cubic feet discharged per day.	50 lb. Value at 23 ct. per 100 cu. ft.	65 lb. Cubic feet discharged per day.	65 lb. Value at 23 ct. per 100 cu. ft.	85 lb. Cubic feet discharged per day.	85 lb. Value at 23 ct. per 100 cu. ft.
1-16	153	$ .35	167	$ .38	198	$ .45
1-8	613	1.31	667	1.53	760	1.74
1-4	2,467	5.77	2,667	6.13	3,066	7.05
1-2	9,867	22.79	10,667	24.53	12,266	28.21
3-4	21,333	49.07	24,400	56.12	28,000	64.40
1	39,466	90.87	42,667	98.12	49,066	112.85

Cement Lined Pipe at Concord, N. H.—Of the 71 miles of main pipes in the water system of Concord, N. H., on Jan. 1, 1920, 11.3 miles or 16 per cent are cement lined. Practically all of the pipe was installed prior to 1888. The earliest installation, according to the 1919 report of P. R. Sanders, Superintendent of Water Works, was in 1872 when 501 ft. of 26-in. pipe was laid in Washington St. In 1882, 1,229 ft. of 6-in., 3,290 ft. of 12-in., and 11,391 ft. of 18-in. pipe were laid.

Reducing Operating Costs of Pumping Plants in Small Towns*

By CHARLES BROSSMAN,
Consulting Engineer, Indianapolis, Ind.

The rebuilding of water works may involve a multitude of problems, but it is of especial interest as related to some of the smaller plants, as these towns have a harder time to make ends meet as compared with the larger city. The small water utility is a harder problem than the larger installation. If such plant be steam operated in a town of from 2,000 to 3,000 population the boiler load usually is very light, the firing periods infrequent, and many times at from 20 to 30 minute intervals, and usually you will find the old compound duplex pumps or even the simple pumps running non-condensing.

Here will be found two large items: namely, coal and labor cost, and with the increased price of both within the past few years it becomes necessary to cut out all the labor possible and decrease the power cost to the minimum. I will illustrate how this has been done in several cases and what the results have been. In order that this may not be a theoretical comparison, I will take as the first illustration the town of Delphi, Ind. Before being called on this work many different schemes had been advanced to cut the operating cost, such as installing a large storage tank of 150,000 gal. capacity and to pump during an 8-hour period. Various schemes to pump electrically were also recommended.

In the first place this tank alone would have cost 50 per cent more than the actual cost of their final electric equipment, and the plant would have cost almost as much to operate as under the old method.

Among other methods considered were installing a new high duty steam pump, pumping by different types of electrical equipment, pumping with present equipment and installing a large elevated tank, cutting down the pumping time.

The original cost of operation with the old steam pumps was $4,827.50 per year. Using electric driven pumps, making the plant automatic and cutting out all of the labor, it was estimated that the entire yearly cost would be less than $2,000, or a saving shown of $2,800 a year, and with interest and depreciation considered, a possible saving of a little under $2,000 per year.

It is very important in these smaller installations to get proper estimates on the amount of water being pumped, for if this is not done and the consumption exceeds the estimate, there is likely to be disappointment on the cost of operation. It is necessary that the designer exercise good judgment and obtain all possible information on this subject, not only from the point of proper pumping capacity, but also in order to get the most efficient pump, as on centrifugal installations if there is not the proper relation between capacity and consumption there is considerable loss in power. These matters should all be gone into very carefully.

Another very important item is the question of fire service. Any electric transmission line is subject to break-downs or mishaps for short periods, or the power plant may be out, and in such a case with electric drive the town will be left without water, except for such capacity as is available. Under the Delphi conditions this tank was only good for about 20,000 to 25,000 gal. effective storage when full, and it must be remembered that the power might go off when the tank was at the low point, and it was therefore necessary that some reserve power be provided. In this case oil and gasoline engines were considered, and it was found that the gasoline engine fulfilled the requirements to better advantage than oil, while more expensive to operate it was quicker to start and was much cheaper and would only be used occasionally.

A word of caution should be given in the selection of such reserve power. It is better to pay a little more and get a slower speed engine. In some instances I know of engines operating for a number of days without an interruption, and if you have a bad fire you want something that will stand up to the work.

Owing to the current at Delphi coming from the electric railway this meant 25 cycle current and meant either a 1,500 speed or 750. In order to pump the amount of water desired, about 800 gal. per minute at 100-lb. pressure, this requires a pretty sturdy engine. To run an engine of this size at the rate of 1,500 revolutions did not appeal to the writer at all. Our specifications therefore called for a speed of 750, and this required a 6-stage centrifugal pump, due to the low speed, but we believe the difference has been worth while. Of course, with 60-cycle current our speed could have been 1,200, and we believe this is getting close to the limit for good permanent operation as far as the engine is concerned.

The plant at Delphi is arranged with two 400-gal. Midwest 2-stage diffusor pumps connected to 30-HP. Lincoln motors, speed 1,440 r.p.m. pumping against about 60-lb. pressure. These pumps are not connected in series, but are used for ordinary fires. The reserve unit consists of a Midwest 6-stage diffusor pump, good for 100 lb. pressure at 750 revolutions. This pump has a 75-HP. Lincoln motor connected with jaw clutch on one end, and on the other end for reserve power a 6-cylinder 5¾x7-in. Wisconsin gasoline motor complete with electric starter. In case of a break-down the gasoline engine can be operated either for fire pressure, in which case it can be speeded up if necessary, or it can be operated at a lower speed and used for domestic pressure in case the power is off. The engine is turned over about once a week for a short time. The generator for charging the battery is connected to one of the domestic pumps, so that the battery is always kept well charged, ready for starting.

The entire cost of this work installed was about $11,000. By it, all labor has been dispensed with, and this amounted to $1,680 before the plant was started. The 1918 cost of coal amounted to almost $4,000 per year; for the year 1917 it was about $3,100. Taking the latter figures, these two items of labor and fuel amounted to approximately $4,800. The actual cost of current to operate these pumps the first few months was about $40 per month. This was on the old off-peak 2-ct. rate, but after contracts had been let for the plant, the matter of rates was brought up by the power company before the public service commission, and after adjustment the average cost per month will now amount to about $75, or about what they used to pay one fireman. This is the entire total operating cost of this plant, or about $900 per year. Therefore, the present operating cost is to the old operating cost as $900 is to $4,800, or there is almost $4,000 a year difference. Of course, to this must be added the interest and depreciation, which would amount to approximately $900 a year. It will therefore be seen that the changing to electric service has been a very good investment for the city of Delphi.

In all the above calculations it should be remembered that a superintendent of water works is required and that he is still retained, and what slight attention the present pumps need, such as oiling, is done by the superintendent but the plant requires very little attention.

Another plant, but slightly differently arranged, is the one designed by the writer for Rochester, Ind. This consists of two 500-g.p.m. DeLaval pumps and 40-H.P. G. E. motors and one 1,000-g.p.m. DeLaval pump and 60-HP. motor. These pumps are arranged so that they can all be operated for domestic consumption, giving a total capacity of 2,000 g.p.m. This gives standpipe pressure and can also be used for fires, where pressure not over 50 lb. is suitable. In case high pressure is required the two 500-gal. pumps are operated in series with the 1,000-gal. pump, giving 1,000 gal. at about 100 lb. pressure. In this plant it was necessary to do something to replace the old machinery. The local power company made a proposition to pump all the water for $3,600 per year, and attend to the plant, and this contract is now in effect. The former cost of operation with the steam pumps was about $4,800 per year. This plant has as reserve its old steam pump and boiler. It would have been necessary for the city to have installed some kind of new equipment, and with the proposition made by the local power company the electric drive was thought more advisable. While the steam reserve does not allow a very quick starting up in case of accident with the transmission lines, in this case the possibility of power being out was small, as it is only a short distance to the local power plant, and any break in the transmission could speedily be located and repaired, and it was thought that the supply in the standpipe would be sufficient to tide over such periods.

Another small water works plant in a town having a population of only 1,200 would be of interest and mention is made of the town of Van Buren, Ind., which purchases current at 2½ ct. per k.w.h. for pumping purposes. Two triplex pumps were installed, each of 125 g.p.m. and geared to a 10-HP. slip-ring motor. These pumps are both controlled by a special design of automatic control, having two regulators for each outfit. The pumps discharge into the main and are connected to a pressure tank of 5 ft. diameter by 20 ft. long. This system has about 9,000 ft. of mains, 18 fire hydrants, and the entire plant was installed for $9,500. The plant is operated by the town marshal, who is also the street commissioner. His water works duties consist of oiling machinery, and $20 per month of his salary is charged against the water plant. Power averages $15 per month, and the entire of operation, including interest at 5 per cent and depreciation at 1½ per cent is estimated at $1,085 per year. This shows that such a plant can be operated on a paying basis. The entire operation of the plant has been satisfactory in every way and the town is greatly pleased with its success.

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*From a paper presented at the recent convention of the Indiana Sanitary and Water Supply Association.

Types of New Jersey Water Treatment Plants and Tests Made by Them

Information as to types of water treatment plants operated in New Jersey and tests made at these plants is summarized in a table in the recently issued 42d annual report of the New Jersey State Department of Health, of which H. P. Croft is chief engineer. The following is taken from the table:

Type of water treatment plants.	Total number of plants.	Number of plants making daily determination for—						
		Alkalinity. (1)	Color and turbidity. (2)	Bacteria. (3)	Free chlorine. (4)	Oxygen consumed, etc. (5)	Bacteria.* (6)	Complete chemical analysis.* (7)
Plants for removal of bacteria only:								
Chlorine disinfection for emergency	2	..	..	..	..	..	.	.
Hypochlorite disinfection of well water	1	..	..	..	..	..	.	..
Chlorine disinfection of surface water	16	..	2	2	..	..	2	..
Hypochlorite disinfection, with mechanical filtration (gravity type) for emergency	1	..	..	..	..	..	1	..
Plants for removal of carbon dioxide:								
Aeration and lime treatment	1	..	..	..	..	..	..	..
Plants for removal of iron:								
Aeration and sedimentation	1	..	..	..	..	..	..	..
Aeration and mechanical filtration (pressure type)	6	..	..	..	..	..	..	..
Permutit pressure filtration	1	..	..	..	..	..	..	..
Aeration and mechanical filtration (gravity type)	10	..	..	..	..	..	..	..
Aeration, sedimentation and mechanical filtration (gravity type), with chlorine disinfection for emergency surface supply	2	..	..	..	..	..	..	..
Aeration, sedimentation and mechanical filtration (gravity type)	1	..	..	..	..	..	..	..
Aeration, sedimentation and mechanical filtration (gravity type) with hypochlorite disinfection for emergency surface supply	1	..	..	..	..	..	..	..
Lime, sedimentation and mechanical filtration (pressure type)	1	..	..	..	..	..	..	..
Aeration, lime and mechanical filtration (gravity type)	1	..	..	..	..	..	..	..
Plants for removal of bacteria, color and turbidity:								
Slow sand filtration	2	..	..	..	..	..	..	..
Mechanical filtration (gravity type)	1	..	..	..	..	..	..	..
Mechanical filtration (pressure type) and hypochlorite disinfection	2	1	2	..	1	..	1	..
Mechanical filtration (pressure type) and chlorine disinfection	3	1	2	..	..	..	1	..
Mechanical filtration (gravity type) and hypochlorite disinfection	6	4	5	2	2	1	..	1
Mechanical filtration (gravity type) and chlorine disinfection	8	7	7	4	4	3	1	3
Mechanical filtration (pressure type) and lime with aeration and sedimentation for iron removal	1	1	1	..	..	..	1	..
Aeration, sedimentation, mechanical filtration (gravity type) and chlorine disinfection	1	1	1	..	..	..	1	..

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*Number of plants making weekly or monthly determination for—

Cost of Meter Reading and Upkeep

Unit costs for meter reading and maintenance, making out and collecting bills and the like are seldom available in such detail as they were presented by Dow R. Gwinn, president and manager of the Terre Haute (Ind.) Water Works Co., in a discussion of the paper, "Water Meters, Service and Repairs," at the thirteenth annual meeting of the Indiana Sanitary and Water Supply Association, held recently. The following abstract of his discussion sets forth the practice of the company with which Mr. Gwinn is connected.

The meters are owned by the company and set free of charge. They are kept in repair without cost to the consumer, unless the damage is caused by hot water from the consumer's premises. Ordinary sized meters are tested on 1 16-in. and full streams before being set. They are also tested when removed and before they are opened. The company has a standing offer on the meter bills to test meters in the presence of consumers free of charge. Practically all meters are repaired in our shop, the exception being large meters, such as 4-in. and 6-in.

When a meter reading indicates an unusual consumption, a printed postal card is mailed to the consumer before the bill is delivered. An offer is made to send one of our men to make an inspection free of charge. We think it is good policy to advise the consumer as early as possible, so that if he has a leak, repairs can be made without delay. When requested to do so, we take a second reading and send a printed postal, showing both readings.

In unusual cases, we take daily readings and use the aquaphone in an effort to locate underground leaks. In some cases, when a meter is registering slowly and no leaks are found in the house, the stop and waste at the point where the service enters the cellar, is closed and the meter watched. With our sandy soil, underground leaks may continue for quite a while without showing on the surface. Every reasonable effort is made to assist in locating leaks so that the consumer can have repairs made and reduce the consumption to normal. All meters are read monthly and bills rendered covering that period.

The cost of repairing, testing and maintaining meters in the year 1919 was $522.61 for material and $1,721 for labor, a total of $2,243.61. As we have 7,700 meters in use, the average cost per meter was about 29 ct.

The expenses on customers' premises were as follows:

Inspecting plumbing	$ 304.25
Investigating large bills and service	935.91
Turning off and on	2,694.62
Changing the meters for test	20.20
Removing and setting meters	479.45
Total	$4,434.42

Average for 7,900 consumers, 56 ct.

The cost of reading meters in 1919 was $2,600.06; average per meter per year, 34 ct.; average per meter per month, a little less than 3 ct. Cost of delivering bills in 1919 was $1,289.96; average per bill per year, 16.6 ct.; average per bill per month, 1.4 ct. Cost of office clerks making out bills, receiving payments and taking care of customers' bills for 1919 was $5,417.92, or an average of 69 ct. Cost of repairing leaks and changing service connections from main to curb in 1919 was $546.51 for material, and $710.96 for labor, a total of $1,257.47; average per service, 15.9 ct.

We are 97 per cent metered. Our minimum monthly rate for ⅝-in. meters is 75 ct., for which the consumer is allowed 3,000 gal. during the month, or 100 gal. per day.

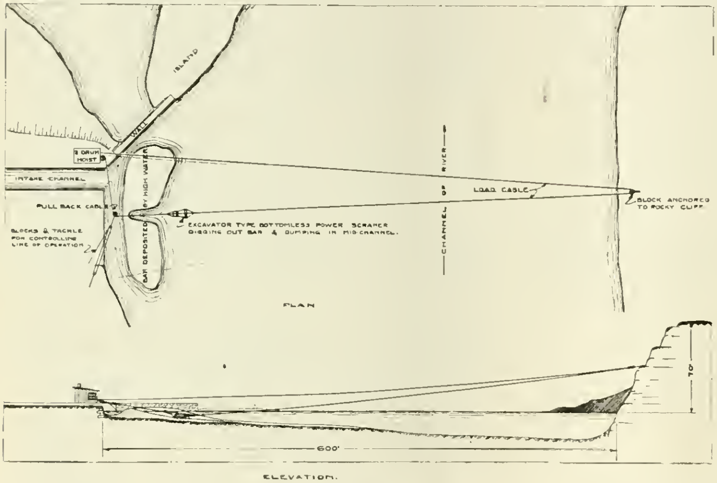
In 1918, 63 per cent of all our metered bills were not over 75 ct. per month. The summer of 1919 was an unusually dry one, and yet the average monthly meter bill for the entire year was only $1.94. Leaving out the 63 industrial and railroad consumer bills, the average per month for all the balance was $1.27. We contend that so long as our average bills do not exceed these amounts, it is practically impossible to make money in the water works business under present conditions. For instance, we are required to furnish and maintain the service pipe from the main to the curb, and also furnish and maintain the meter. For small service pipes, we use ⅝-in. extra strong lead pipe, inverted key curb cocks with lead flanges and tail pieces and Buffalo curb boxes. Most of our meters are set on the grass plot near the curb. We are using for this purpose two 20-in. by 24-in. sewer pipe with an iron cover having an 8-in. opening or throat.

The average cost in the year 1918 for a service from the main to the curb, including the meter and installation, was $42.27. The present cost is higher, due to the increased cost of material. In other words, where it is necessary to put in an installation of this character, we are required to invest over $42, in addition to our general investment for pumps, boilers, filters, buildings, reservoirs and street mains, to get a customer who will pay us, say a dallor or a little over per month. In my opinion, the rate is not sufficient when the investment and character of service are considered.

Power Scraper Outfit Removes Obstructions from Intake Channel of Power Plant

When a power plant obtains its water supply through an intake from a river or pond, it frequently has to contend with periodical accumulations of material that block up the intake channel.

Various methods have been employed for keeping the intake free from such obstructions. The Rochester Gas & Electric Corporation, Rochester, N. Y., has obtained very satisfactory results during the past few years with a ¾ cu. yd. Sauerman bottomless power scraper operated by a 60-HP. double-drum electric hoist, installed as shown in the accompanying diagram.


ISLAND
WALL
2 DRUM HOIST
INTAKE CHANNEL
PULL BACK CABLE
BLOCKS & TACKLE FOR CONTROLLING LINE OF OPERATION
BAR DEPOSITED BY HIGH WATER
EXCAVATOR TYPE BOTTOMLESS POWER SCRAPER DIGGING OUT BAR & DUMPING IN MID-CHANNEL.
CHANNEL OF RIVER
LOAD CABLE
BLOCK ANCHORED TO ROCKY CLIFF
PLAN
70'
600'
ELEVATION.

Plan and Elevation of Power Scraper Installation for Removing Bar at Intake Channel.

Conditions at the Rochester plant generally require the operation of the power scraper only for a short period once a year. This is right after the high water season when a gravel bed begins to form in the river in front of the intake water tunnel. The bottomless scraper is operated back and forth over this deposit, scraping the gravel out into deep water until it has cut a channel of sufficient depth to last until the next high water period. When this operation is completed, the equipment is taken down and placed in storage.

City Operates Printing Plant.—Practically all of the city printing of Pasadena, Calif.—annual reports, ordinance books, etc.—is done in a shop owned by the city. The work in the plant is restricted to city government work, and it does not in any way enter into the commercial field. The shop was started in 1914 and up to June 30, 1919, it had saved the city $5,773 in printing costs, and in addition had accumulated a surplus of $1,484. The total investment for equiment has been $3,970.

A Hydraulic Experiment that Failed.—Boys in Winchendon, Mass., recently built a brick dam 3 ft. high across a brook and got a 2 ft. head of water, which they guided through an 8-in. tile pipe and small trenches into the grounds of the Marvin School, 200 ft. away, and then through a window into the school house cellar, which the janitor found filled waist-deep. He made the discovery on a Saturday, however, so that the boys didn't get a week's vacation.

Opportunities for American Engineers in Foreign Countries*

By FRED LAVIS,
Consulting Engineer, New York City.

The United States, previous to the war, had always been largely concerned with domestic development, even in its great inventions and industrial methods. The development of the world outside of the United States was in the hands of Europeans. The direction of foreign engineering enterprises has been in the hands of Europeans. The reason for this is that these countries have supplied the many supplies, also the executives, the engineers, etc., to direct the enterprises, and until this is done by the United States, American engineers will not have a large part in these foreign developments.

It must be fully realized that before a nation can participate in the development of foreign enterprises to any great extent, it must develop among its own people the desire to buy the stocks and bonds of these enterprises. That desire is something which hardly exists today in the United States.

Since the war and the great increase in available money in the United States opportunity for this country in foreign trade has developed. Our failure to realize our opportunity has been largely in the matter of finance and the extension of credits.

In the construction of railways, especially in undeveloped or partially developed countries, I believe our engineers, by virtue of their experience and training, are pre-eminent. We know better, or at least we practice better, the art of adapting the railroad to the work it had to do than do European engineers.

Another important foreign field which American engineers are well able to take care of is that of the development of electric power. To say the least, we are, I believe, as well able to cope with these problems as the Europeans.

In the matter of the development of oil fields and the construction of pipe lines our engineers are leaders. It has been very interesting to note recently that we are today directing the construction of a pipe line between Havre and Paris in France.

There is the field of sanitation and municipal engineering also, which is only just beginning to open up. The principal cities of South America are fully alive to the need of good water supplies, the need of proper systems of sewers, of proper paving.

In the matter of highways also, of course, the whole world is waking up to the changes brought about by the use of motor trucks and the need of good roads.

In looking over the foreign field itself, so far as American engineers are concerned, our first thoughts inevitably turn to South America, Mexico and Central America. A fairly large number of us know those countries and have been more or less at home in them. American engineers have done work in all of them and on the whole their people like us.

South and Central America and Mexico are attractive fields for us because they are our nearest neighbors and we know them. They need outside help for their development, just as we needed it in the past. Besides money, however, which of course is the sine qua non, they need our technical skill and our organizing ability. The field there in almost every line of engineering endeavor is limited only by the amount of money we are willing to invest.

I think that on the whole, with the exception of Spain, the Balkans and Russia, we can pretty nearly entirely eliminate Europe from the field of possibilities abroad for American engineers.

Russia and the Balkans will undoubtedly open up a field for our activities as soon as they are able to establish safe and sound governments. Before the revolution in Russia, we were already investigating some very important transportation, coal development and steel manufacturing projects there, which were more or less linked up together, but these countries are off the map for the present.

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*From an address at the 6th annual convention of the American Association of Engineers.

Of all the European countries today, Spain presents the most attractive field. Her material development is probably the most backward of any of the European countries except the Balkans. She has a good laboring population, large undeveloped natural resources and since the beginning of the present century has been making remarkable progress toward economic prosperity which has been greatly accelerated during the war.

We come now to Asia, and without going into details it may be said at once that the great fields there are Siberia and China. The future of Siberia is inevitably linked up with the future of Russia. It is an enormous country with the characteristics of our great Northwest and Canada, and will open up some day, perhaps a little distant, a great field for American enterprise, particularly in connection with the construction of railways and the development of its great resources of mineral wealth. As in China, we shall be faced to some extent with the competition of the Japanese, but in this the question of investments will be the deciding factor.

China is in many ways a most interesting country to Americans. It has a population of 330 to 340 millions of people, only about 7,000 miles of railways, an area 50 per cent larger than that of the U. S., and hardly any organized industries except, perhaps, in the production of tea and silk. It is just beginning to awake to its possibilities and would welcome, in fact is welcoming, American aid in the development of its enormous resources of cheap, efficient labor and great natural resources.

The engineer who goes abroad should be able to associate with the well educated, eminent foreign engineers, with bankers, cabinet ministers, presidents and with kings with just the same right degree of cordiality as he does with a contractor, a drill runner or the driver of a team of mules. This savoir faire, this knowledge of how to meet any condition of life, will also do him no harm at home

Knowledge of a foreign language is not absolutely essential, but is most eminently desirable. Not the mere learning of a language for the purpose of reading foreign technical literature, but knowing a language well enough so as to get at the real heart of foreign people. Until we live in foreign countries, talk to their people in their own language and thoroughly understand them, we shall be handicapped in doing business with them. Personally, although I realize the immediate value of Spanish in many enterprises, I am firmly convinced that our boys in school will get on the whole more value from French than any of the other foreign languages, when they know only one.

We need, as engineers, a broader culture all round. We should not disdain a dress suit, frock coat, a silk hat or patent leather shoes, and we should have the manners which go with them, not acquired for the occasion, but used as a matter of course. Perhaps some of you may resent this as unnecessary: for some of you it is. For many of our engineers, and I think I have seen as many of them abroad as anyone, it is not unnecessary, it needs to be said.

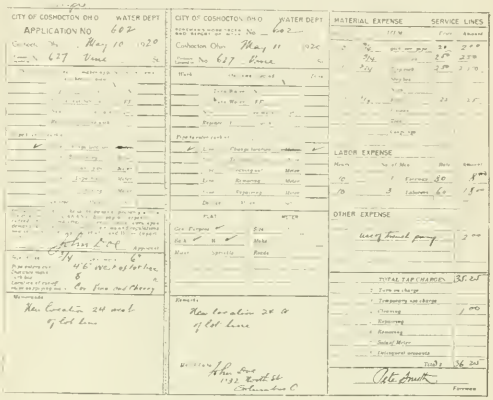
Engineers who wish to do something more than run a transit or figure the strains on a bridge, should have a fair knowledge of world politics, of world history. They should know what the main currents of commerce are and where they run, they must have a knowledge of business and of methods and customs of finance and not be afraid of knowing something of art, of paintings, of statuary, of literature as well as of science.

The answer to the question as to the opportunities for American engineers in foreign countries can be summed up very briefly. The opportunities today are rather limited. I believe they will increase somewhat slowly for a while, then with growing rapidity. In the past America has had no incentive to develop foreign trade and particularly no incentive to encourage the development of foreign enterprises requiring capital.

As we become more and more a manufacturing nation, as we need more and more to import food supplies, we shall be forced into the foreign field and our interests will expand in every direction. I think the countries offering the greatest opportunities today are South America and Spain and in the not far distant future China, Russia and Siberia. The crux of the whole question is the desire and ability of the investing public to absorb foreign securities. As they do this so will our activities expand.

Application Form for Water Service Changes

A form that has been found very useful by the Water Department of Coshocton, O., is illustrated below. All work on service lines is charged at cost by the department. The form was designed by Ray S. Blinn, Director Department of Public Service and Safety.



CITY OF COSHOCTON OHIO WATER DEPT

APPLICATION NO 602

May 10 1920

627 Vine St

John Doe Applicant

Memoranda

New location 24 west of lot line

CITY OF COSHOCTON OHIO WATER DEPT

No 602

Coshocton Ohio May 11 1920

No 627 Vine

Remarks

New location 24 w of lot line

John Doe
1132 North St
Columbus O

MATERIAL EXPENSE SERVICE LINES

LABOR EXPENSE

OTHER EXPENSE

use of trench pump 2 00

TOTAL TAP CHARGES 35.25

Totals 36 25

Pete Smith
Foreman

Combination Blank for Consumers' Application. Foreman's Work Order and Cost Keeping. Actual Size of Form, 8½x10½ In.

Corrugated Pipe Outfall Sewer at Bay City, Mich.

The disposal of the sewage from a residential section of Bay City, Mich., created quite a nuisance when discharged into a sluggish portion of the Saginaw River. How this was remedied is told by L. R. Newnham, in a recent issue of The Highway Magazine, from which the following is taken:

The sewage flow from this district originally was carried to the upstream side of a roadway embankment which jutted into the river 900 ft. The current of the stream above the embankment was insufficient to carry away waste matter emptied into the water along the shore.

Owing to the exceptionally flat character of the country, wide shoals extended into the stream some distance from either bank. Sewage poured onto these flats, which are covered by shallow water except in the mid-summer, when they become dry, had a tendency to shoal and form sludge beds. The existence of a considerable current in the center of the river caused the city to install 900 ft. of 30-in. corrugated culvert pipe. This pipe now serves to deposit the sewage in the center of the stream, where it is taken care of by dilution. The original pipe was laid in shallow water and had been damaged by ice.

The new pipe is held in position on one side by the earthen bank, on which the road is built, and on the other by piles. The piles prevent the pipe from rolling down into the deep water, and at the same time serve to keep it straight. It is not fastened to the piles in any way, except at the outlet, where it is secured by means of a chain. A pile driver was used to drive the piles and also to lower the 30-ft. sections of pipe into place after the connecting bands were secured. The entire 900 ft. was delivered in 30-ft. sections.

The corrugated pipe rests evenly on the uncertain muddy bottom of the river, where a heavier piece of construction would slowly settle and perhaps crack.

The installation was made by W. C. Grisdale, of Bay City, Mich., under the supervision of Engineer H. C. Thompson.

Organizing Conference Adopts Constitution for Federation of Engineering Societies

By a vote of 88 affirmative to no negative, and with about 20 or 40 delegates refusing to vote, the Organizing Conference at Washington, D. C., on June 4, adopted a constitution and by-laws for a new national engineering organization—to be known as The Federated American Engineering Societies. These instruments will come up before the various national and local engineering and allied associations for adoption. The constitution and by-laws follow:

CONSTITUTION OF A NATIONAL ENGINEERING ORGANIZATION.

ART. I.—NAME.

The name of this organization shall be The Federated American Engineering Societies.

ART. II.—OBJECT.

Service to others is the expression of the highest motive to which men can respond, and duty to contribute to the public welfare demands the best efforts that men can put forth.

Therefore, it shall be the object of this organization to further the interests of the public through the use of technical knowledge and engineering experience, and to consider and act upon matters common to the engineering and allied technical professions.

ART. III.—MEMBERSHIP.

Sec. 1. Scope. The membership shall consist of national, local, state and regional engineering and allied technical organizations and affiliations, classified as follows:

(1) National engineering and allied technical organizations.

(2) Local, state and regional engineering and allied technical organizations other than local associations, sections, branches or chapters of national organizations.

(3) Affiliations consisting of any one, or a combination, of the following constituents:

(a) Local sections and associations of members of national organizations included under (1).

(b) Local engineering and allied technical societies and clubs, not of national scope.

(c) Local engineers and members of allied technical professions and their associates.

Sec. 2. Qualifications. The qualifications for membership shall be as provided in the By-Laws.

Sec. 3. Application for Membership. Application for membership shall be made in the form and manner prescribed in the By-Laws.

Sec. 4. Termination of Membership. The membership of any constituent organization may be terminated by it or by the Council in the manner provided in the By-Laws.

ART. IV.—MANAGEMENT, AMERICAN ENGINEERING COUNCIL.

Sec. I. The management of this organization shall be vested in a body to be known as the "American Engineering Council," and its Executive Board.

Sec. 2. Functions. The American Engineering Council shall consist of representatives of Member Societies selected as hereinafter provided. This Council shall co-ordinate the activities of state councils and of local affiliations whenever these activities are of national or general importance or may affect the general interests of engineers.

Sec. 3. Representation. Each national, local, state or regional organization, or affiliation, shall be entitled to one representative on the Council for a membership of from 100 to 1,000, inclusive, and one additional representative for every additional 1,000 members or major fraction thereof; provided that in the determination of the representation of local, state or regional organizations or affiliations no count shall be taken of any organization which is represented individually or through another local, state or regional organization or affiliation; and, provided further, that no organization shall have more than 20 representatives on the Council.

Sec. 4. Selection of Representatives. Representatives on the Council shall be selected as stipulated in the By-Laws.

Sec. 5. Meetings. The Council shall hold an annual meeting. Other meetings may be called by the Executive Board and shall be called by it upon the written request of 25 representatives on the Council.

Sec. 6. Officers. The elected officers of the Council shall consist of a President, to hold office for two years, and who shall be ineligible to re-election; four Vice-Presidents, to hold office for two years, two to be elected every year, and a Treasurer, to hold office for one year. These officers shall be elected by a letter ballot of the Representatives on the Council as provided in the By-Laws. There shall be an Executive Officer who shall also be Secretary appointed by and holding office during the pleasure of the Executive Board. He shall not be a member of the Executive Board but may be a representative on the Council.

EXECUTIVE BOARD.

Sec. 7. Functions. There shall be an Executive Board of 39 members of the Council constituted as hereinafter provided and charged with conducting the business of the organization under the direction of the Council.

Sec. 8. Membership. The Executive Board shall consist of 30 members, of whom 6 shall be the officers elected by the Council and 24 shall be selected, a part by the national societies and the remainder by the local, state or regional organizations or affiliations according to districts, as provided in the By-Laws; provided, that the number of representatives of the national societies on the Executive Board shall bear as nearly as may be the same ratio to the number of representatives of local, state and regional organizations or affiliations as the number of representatives of the national societies bears to the number of representatives of the local, state and regional organizations or affiliations on the Council.

Sec. 9. Electoral Districts. For the purpose of facilitating the selection of the district members on the Executive Board, the Council shall divide the country into districts as provided in the By-Laws, based upon an equitable representation, having regard to both its membership and area.

Sec. 10. Officers. The President and Secretary of the American Engineering Council shall be respectively the Chairman and the Secretary of the Executive Board. There shall be two Vice-Chairmen elected by the Board from its members.

ART. V.—UNEXPIRED TERMS.

Vacancies in the offices of the President, the Vice-Presidents, the Treasurer and in the Executive Board and among the representatives on the Council shall be filled as soon as feasible by the agencies originally selecting the incumbents. Officers and delegates thus chosen shall serve for the unexpired terms.

ART. VI.—FUNDS.

Sec. 1. Funds for the use of the organization shall be contributed as follows:

(a) Each national society represented on the American Engineering Council shall contribute annually one dollar and fifty cents ($1.50) per member.

(b) Each local, state or regional organization or affiliation represented on the Council shall contribute annually one dollar ($1.00) per member. No portion of such funds shall be applied to the use of local affiliations or state councils.

Sec. 2. The American Engineering Council may receive and administer gifts, bequests or other contributions for carrying out the purposes of the organization.

ART. VII.—LOCAL AFFILIATIONS.

Sec. 1. Object. The American Engineering Council shall encourage the formation of local affiliations, to consider matters of local public welfare with which the engineering and allied technical professions are concerned, as well as other matters of common interest to these professions, in order that there may be united action and that suggestions and advice may be offered to the Council.

Sec. 2. Constitution. Each local affiliation desiring membership in this organization shall submit its Constitution and By-Laws and all subsequent amendments thereto to the Executive Board of the Council for approval of such portion thereof as may affect its eligibility, or its relation to the work of the Council.

ART. VIII.—STATE COUNCILS.

Sec. 1. Object. State Councils, consisting of representatives of local affiliations within the state or otherwise representative of the majority of engineers and members of allied technical professions in the state, if members of this organization, shall consider state matters of public welfare with which the engineering and allied technical professions are concerned, as well as other matters of common interest to these professions, in order that there may be united action in state affairs.

Sec. 2. Constitution. Each State Council desiring membership in this organization shall submit its Constitution and By-Laws and all subsequent modifications thereto to the Executive Board of the Council for approval of such portion thereof as may affect its eligibility, or its relation to the work of the Council.

ART. IX.—DELIMITATION OF AUTHORITY.

Local affiliations, state councils and the American Engineering Council shall deal with local, state and national matters respectively, and they shall be autonomous with respect thereto. It shall, however, be the duty of the American Engineering Council to interest itself in the activities of local affiliations and state councils if such activities are of national scope, or affect the general interest of the engineering and allied technical professions: provided, that nothing herein stated shall be construed as preventing the discussion by any local affiliation or state council or by the American Engineering Council of any matters of interest to engineers and members of allied technical professions, or action by the said Council on local or state matters where no local affiliation or state council exists.

ART. X. PUBLICITY.

This organization stands for open meetings and such publicity as the By-Laws provide.

ART. XI. AMENDMENTS.

Sec. 1. An amendment to this constitution may be proposed by the Executive Board.

Sec. 2. An amendment may be proposed in writing by at least 25 representatives on the American Engineering Council; such amendment shall be considered first by the Executive Board, which may approve, disapprove or formulate a modified or alternative amendment, report of which action shall accompany the original proposal to this organization.

Sec. 3. Any amendment proposed as provided in Sections 1 and 2 shall be considered at a meeting of the American Engineering Council and shall be submitted to its members at least 90 days in advance of such meeting. At this meeting, provided a majority of the representatives are present, the amendment may be rejected, or ordered submitted to the members of the Council for letter ballot within 30 days thereafter, with such modifications as may be adopted by a majority of those present. The amendment shall fail of adoption if one-third of the votes cast are in the negative.

BY-LAWS.

CHAP. I. MEMBERSHIP.

Sec. 1. Qualifications. Any society or organization of the engineering, or allied technical professions, is eligible for membership, the chief object of which is the advancement of the knowledge and practice of Engineering or the application of allied sciences, and which is not organized for commercial purposes.

Sec. 2. Admission. The Executive Board shall submit each application made to it on its prescribed form, to a letter ballot of the American Engineering Council, accompanied by a statement of its findings as to eligibility and the number of representatives to which the applicant would be entitled. The applicant shall be admitted by a majority vote of the Council, provided that not more than 25 per cent of the members of the Council shall vote in the negative.

Sec. 3. Termination of Membership. Any member society may terminate its membership on June 30 or December 31 of any year by at least three months' written notice to the Secretary; and, provided, the financial obligations of such organization are discharged to the said June 30 or December 31, respectively.

On complaint brought by any three members of the Council, and transmitted in writing to the Secretary of the Executive Board, alleging reasons why the membership of any member society should be terminated, the Committee on Membership and Representatives of the Executive Board shall investigate said charges, inform itself of all matters pertaining thereto, and report its findings to the Executive Board. The latter may dismiss the proceedings or make recommendations to the Council. The Council, by a two-thirds vote of those present at a meeting, may dismiss the proceedings or order a letter ballot; when the latter is taken, a two-thirds vote of the Council shall be necessary to terminate the membership.

CHAP. II. MANAGEMENT.

Sec. 1. Terms of Representatives. Representatives on the American Engineering Council shall serve for two years; provided, that after the first election, where there is more than one representative from one organization, approximately half shall be elected each year.

Sec. 2. Announcement of Representatives. Each organization represented shall send to the Secretary of the Council on or before August 15th of each year the names of its representatives who are to serve for the term beginning January first following.

Sec. 3. Votes of Representatives. Representatives on the Council and on the Executive Board shall each have one vote on these bodies.

Sec. 4. Meetings. 1. At all meetings of the National Council the order of business shall be as follows:

a. Roll call of Representatives.
b. Approval of minutes of last meeting.
c. Report of Secretary.
d. Report of Treasurer.
e. Report of President.
f. Report of Executive Committee.
g. Report of other committees.
h. Unfinished business.
i. Special business.
j. New business.

2. Rules of Order. Unless otherwise provided, Roberts' Rules of Order shall govern the procedure of all meetings of the Council.

3. Quorum. A majority of all of the representatives of the Council shall constitute a quorum for all of its meetings.

Sec. 5. Nomination and Election of Officers. 1. The Secretary shall send to each member of the Council at least 90 days in advance of the annual meeting nomination blanks for offices to be filled at that meeting. Nominations received within 30 days shall be canvassed by the tellers appointed by the Executive Board and reported by them to the Board. The Board shall place upon the ballot the names of the three candidates receiving the highest number of votes.

2. The Secretary shall mail to each member of the Council, at least 30 days before the annual meeting a ballot containing the names of the nominees for each office.

3. Ballots received before 7 a. m. of the first day of the annual meeting shall be canvassed by tellers appointed by the Executive Board, and the result certified to the President of the Council, who shall announce the result of the election at the annual meeting. A plurality of votes shall elect; in case of a tie vote the annual meeting shall select immediately between the tied candidates by ballot.

Sec. 6. Duties of Officers. 1. The terms of all officers elected at an annual meeting of the Council shall commence on the adjournment of such meeting.

2. The officers shall have the usual duties pertaining to their respective offices, except as may be otherwise provided in the Constitution and By-Laws.

3. It shall be the duty of the President to represent the Council on any formal occasion.

4. The Vice-Presidents, in the order of their seniority of election and age, shall, in the absence or disability of the President, discharge his duties.

5. The Treasurer shall receive all moneys and deposit same in the name of the Council with a bank or trust company approved by it. He shall invest all funds not needed for current disbursements as ordered by the Executive Board. He shall pay all bills covering expenditures authorized by the budget or the Executive Board, by checks countersigned by the Chairman of the Finance Committee or some other member thereof. He shall make an annual report and such other reports as may be prescribed by the Executive Board. He shall give a bond at the expense of the Council, in amount and with surety satisfactory to the Executive Board.

6. The Executive Officer shall be appointed and his compensation fixed annually by the Executive Board and shall hold office during its pleasure. He shall be the Secretary of the Council and of its Executive Board. He shall manage the business of the Council under the direction of the Executive Board, and perform such duties as may be assigned to him by the Council or the Executive Board. He shall be the custodian of the property of the Council. He shall collect all moneys due the Council and transfer them to the custody of the Treasurer. He shall scrutinize all expenditures and use his best endeavors to secure economy in the administration of the business of the Council. He shall certify to the accuracy of all bills or vouchers on which money is to be paid. He shall give a bond at the expense of the Council in amount and with surety satisfactory to the Board. He shall pay the current expenses of the office and for this purpose shall have at his disposal a suitable sum of money to be fixed by the Board, which amount shall be periodically replenished under the authority of the Finance Committee upon the presentation of an account of disbursements in the form required by it. He shall mail to the member societies bills for their annual contribution 30 days prior to the beginning of the fiscal year. He shall perform such other duties as may from time to time be assigned to him by the Council or the Executive Board.

Sec. 7. Selection of Executive Board. 1. The Secretary shall submit to the Executive Board, at its September meeting, a list of member societies in good standing with their respective memberships.

2. The Executive Board shall thereupon determine the number of its members for the next ensuing administration year to be selected by national societies, and by the representatives of the local, state or regional organizations or affiliations, such members to be proportioned as near as may be to their respective memberships in good standing, and it shall prescribe the boundaries of each district.

3. The Secretary, within two weeks after the September meeting of the Executive Board, shall mail to the proper officer of each member society a copy of his report on membership and the Board's action with respect to the membership of the Board and its delimitation of districts.

Sec. 8. Attendance on Meetings. If any member of the Executive Board or any committee shall fail to attend five consecutive meetings he shall cease to be a member of such Board or committee.

Sec. 9. Duties of Executive Board. 1. The Executive Board shall organize within 30 days after the adjournment of the annual meeting of the Council.

2. It shall hold regular monthly meetings except during July and August. The regular meeting shall be held on the second Monday of each month except that a regular monthly meeting shall be held in connection with the meeting of the Council.

3. Special meetings may be called at the discretion of the President and shall be called at the written request of five members of the Executive Board.

4. The Secretary shall mail the notices of each regular meeting at least 15 days in advance thereof, and shall mail notices of each special meeting, stating its purpose, at least ten days or telegraph six days in advance of the date. No business, other than that for which it has been called, shall be transacted at a special meeting.

5. A quorum for all meetings of the Executive Board shall be fifteen members.

6. The Executive Board, unless otherwise provided, shall appoint all special committees of the Council and of the Executive Board. The membership of such committees may be drawn from the membership of the Council or of the member societies.

7. The Executive Board shall, whenever practicable, provide for the whole or a part of the expenses of representatives attending meetings of the Council and of the Executive Board.

Sec. 10. Appointment of Committees. 1. The following committees shall be appointed from the membership of the Board annually by the incoming president, with the approval of the Executive Board, each member to serve one year, or until his successor is appointed;

a. On Procedure.
b. On Constitution and By-Laws.
c. On Publicity and Publications.
d. On Membership and Representation.
e. On Finance.
f. On Public Affairs.

Sec. 11. Duties of Committees. 1. The Committee on Procedure shall act for the Executive Board in the interim between its meetings, and shall perform such other duties as may be assigned to it.

2. The Committee on Constitution and By-Laws shall report on all proposed amendments referred to it by the Executive Board, together with any modifications it may deem desirable.

3. The Committee on Publicity and Publications shall, when so requested, prepare all public statements and shall have the direction of publications of the Council.

4. The Committee on Membership and Representation shall report to the Executive Board on eligibility of each applicant for membership and the number of representatives to which it would be entitled. It shall review and report at least 90 days before each regular meeting of the Council the number of representatives to which each member society is entitled. It shall review the existing electoral districts and report thereon to the Executive Board at least once every two years. It shall report on all questions regarding registration and credentials of representatives on the Council.

5. The Finance Committee shall have supervision of the finances of the organization. It shall report an annual budget to the Executive Board. The chairman or some other member of the committee shall countersign all checks for the payment of money.

6. The Committee on Public Affairs shall report to the Executive Board on all public affairs with which the Engineer is concerned or which affect the relation of the Engineer to the public.

CHAP. III. FUNDS.

Sec. 1. Fiscal Year. 1. The fiscal year shall begin on the first day of January of each year.

2. The contributions of each member society shall be payable in advance in semi-annual payments, on the first day of January and July of each year, and shall be based upon a certified statement of its membership as of January first.

3. A member society failing to pay its semi-annual contribution within six months after it is due shall be suspended or dropped from membership, at the discretion of the Executive Board.

4. Funds shall be disbursed, as authorized by the budget or the Executive Board, by checks signed by the Treasurer and countersigned by the Chairman or some other member of the Finance Committee.

CHAP. IV. PUBLICITY.

1. Privilege of attendance at meetings of The Federated American Engineering Societies and the American Engineering Council, except during executive sessions, may be extended to proper persons, who may be authorized to make copies of papers and records.

2. The Publicity Committee may engage a publicity secretary to co-operate with the trade and general press.

CHAP. V. AMENDMENTS.

Sec. 1. An amendment to these By-Laws may be proposed by any representative of the American Engineering Council or of the Executive Board. The latter shall consider all proposed amendments and mail a copy of such amendments, together with its report thereon, to each representative on the Council at least 60 days prior to the date of a regular meeting.

Sec. 2. These By-Laws may be amended by an affirmative two-thirds vote of all representatives on the Council present at a regular meeting thereof; provided that the proposed amendment shall have been mailed to each representative at least 30 days in advance of such meeting.

Sec. 3. Sections 2, 4 (paragraph 1), 5, 6 (paragraphs 3, 4, 5 and 6), 7 and 10, of Chapter II, of these By-Laws, and any By-Laws adopted subsequent to .... may be amended by a vote of three-fourths of the members of the Executive Board at any regular meeting; provided that the proposed amendment shall have been presented in writing at a previous regular meeting of the Board.

Advantages of Ledger Posting Machine in a Water Department.—During 1919 a bookkeeping or ledger posting machine was installed in the Collection Division of the Waterworks of Milwaukee, Wis. All straight accounts are handled mechanically by the machine. The machine prints date, comprised of month, day and year, previous reading, present reading, and automatically makes the subtraction; also prints the extension or amount. Fifteen special characters are provided for printing memorandums, such as high reading, plumbing leak, occupied, vacant, etc., etc. The advantages of the machine are summarized as follows by Osw. J. Ronge, Chief Division of Collections, in the last annual report of the Milwaukee Waterworks.

Ledger cards can be more expeditiously filled in, handling approximately 100 per cent more accounts than by hand.

Much neater and more legible card is produced than when filled in by hand.

Expedites billing, as billing machine operators have less trouble reading printed figures.

On old style ledger cards the present reading or larger reading appeared under previous reading. Subtraction, therefore, was a difficult problem, especially when figures of seven or more digits were encountered. Machine subtracts automatically, requiring no effort on the part of operator and eliminates the continuous mental strain while computing consumers' accounts.

As subtraction is done automatically, it is unnecessary to audit cubic feet consumed to avoid errors.

Organizing Conference at Washington

By FREDERICK H. NEWELL.

Past President of American Association of Engineers.

"To further the interests of the public through the use of technical knowledge and engineering experience and upon matters common to the engineering and allied technical profession" is the declared object of the organization created at Washington on June 3 and 4 to be known as "The Federated American Engineering Societies." Its membership is to consist not of individuals but of existing national, state, local and regional engineering and allied technical organizations and affiliations, each of which is to contribute $1.00 or $1.50 per member and to send representatives yearly to an "American Engineering Council" which in turn has an executive board of 30 members meeting monthly to conduct the business of the organization.

No specific business is as yet outlined for action by the Council, but it is to speak for all engineers on matters of public information and to organize State Councils to discuss state questions. Pending the consideration of the proposed constitution and by-laws, by the various societies interested, the existing Engineering Council will continue its activities. Some time will be required before the proposed American Engineering Council can be formed, as none of the societies or associations has as yet definitely committed itself to the plan.

The American Association of Engineers was well represented at the Washington Conference and in preliminary discussion of the plan opposed the formation of a new body, as its representatives contended that the A. A. E. is now performing most of the functions of the new proposed supersociety. On ballot, however, it voted "Yes" on the question as to whether or not this "should be an organization of societies or affiliations and not of individuals." Later, on the adoption of the proposed constitution, it abstained from action; its 17 delegates—having expressed their doubts as to the wisdom of the plan—did not feel that they should interpose further objection, but let it be tried on its merits. They expressed a willingness to co-operate in the future on any specific matter which might be of interest to the members, but did not believe that the association could or should turn over, say $30,000, to a new body to be used largely in duplicating executive expenses, when results of larger value to the members could be had by using these funds through their own executive machinery.

The success of this American federation of engineering societies is, of course, dependent upon the action of many independent bodies, each of which has need of all of the funds it can secure for its own particular enterprises. The machinery proposed is somewhat elaborate and appears to be cumbersome and expensive so that most of the funds which may be had directly from the societies will be needed for the costs of the monthly meetings of the large executive committee and for the office of the secretary. The men who have been urging the movement are, however, filled with enthusiasm and confident of early success in persuading the smaller as well as the larger societies to join.

The result promises, for a time at least, the operations of two larger all-inclusive bodies of engineers; first, the A. A. E. devoted to service to its members in employment, remunerations, and self help; the second—to be formed—a federation of technical bodies—devoted to more general matters of public concern.

Inspection of Drain Tile for U. S. Reclamation Service

In the construction of tile drains it is of the utmost importance that the strength of tile be sufficient to carry the superimposed load of earth with a good margin of safety. In the May, 1920, issue of Reclamation Record is an article by Walter L. Drager, Assistant Engineer, Denver office, outlining methods of testing and inspection of drain tile, and also a portion of the specifications under which the Reclamation Service purchases its tile. The following is an abstract of the article:

The bad effect on the land from impaired drainage may be very serious and the cost of removing and replacing broken tile amounts to many times the cost of the tile itself. Moreover, a broken tile will allow the backfilled material to wash into the tile line and clog up a section of the good tile, which must then also be removed, cleaned out, and relaid. The expense of doing this is obviously much greater than the cost of original construction of the equivalent length of drain. For these reasons, all drain tile should be accepted only after a thorough test has been made of its crushing strength, and rigid inspection should be made at the time of shipment and again immediately before placing in the trench. The cost of such inspection is of minor importance compared with the beneficial results accruing therefrom.

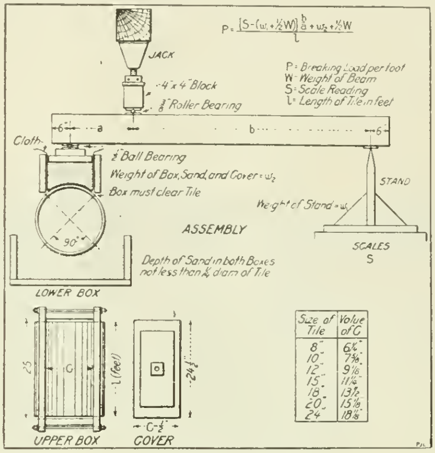
Tile Specifications of U. S. Reclamation Service.—The specifications under which the Reclamation Service purchases drain tile are based upon past experience and tests made by various agencies. The principal physical requirement is crushing strength. No limit is specified for either absorption or thickness of shell, and glaze is of minor importance. This has the advantage of allowing any contractor having a better grade of clay and a good process of burning to decrease the weight of material used, and at the same time a saving to the Government in freight charges may be effected. The following excerpts from the specifications include the principal requirements:

> Each tile shall be of cylindrical section, the size being designated by the interior diameter. The average diameter shall not be more than 3 per cent less than the specified diameter. The maximum and minimum diameters of the same tile and the average diameters of tiles intended to be used adjacent to each other, shall not differ more than 80 per cent of the thickness of the wall. Tile shall be 2 ft. in length. Tile designated to be straight shall not deviate materially from a straight line, and the ends shall be practically at right angles to the center line. Tile shall be reasonably smooth on the inside and free from cracks and checks, extending into the body of the tile in such a manner as to appreciably decrease the strength. Tile stood on end and tapped with a light hammer, when dry, shall give a clear ring. Tile shall be free from chips and broken pieces that will decrease its strength or admit earth in the drain. The ends shall be regular and smooth and admit of the making of a close joint when properly turned and pressed together.
>
> Tile shall be partially salt-glazed, and be burnt to sufficient temperature to vitrify the material and produce strong dense walls.
>
> Tile shall have minimum and average supporting strengths, when tested by the method herein described, not less than the following, in pounds per linear feet:

Size of tile. In.	Minimum.	Average.
8	1.140	1,200
10	1.425	1,500
12	1,710	1.800
15	1,900	2.000
18	2,185	2,300
20	2,470	2,600

Method of Testing Tile.—The sample tile, after weighing and measuring, is embedded in sand in the lower box to one-quarter of its circumference. The upper box is then set in position, lined with cloth, filled with sand, and the cover adjusted. Each part of the apparatus is carefully leveled when placed in position and the sand thoroughly spaded to provide uniform pressure on the tile. The beam is placed in position, resting on a ½-in. steel ball in the exact center of the cover; the other end of the beam is supported on a knife-edge stand on the scales adjusted to correct height to make the beam level. The jack is then clamped down tight upon the roller bearings on the top of the beam in the position shown. Before any additional pressure is applied the upper box must be raised about ¼ in. to clear the tile. The jack is then turned slowly, gradually increasing the pressure on the tile until the breaking point is reached, the proportionate amount of the applied load being measured on the scales. All sand used in making the test must be clean, coarse sand, about No. 8 to No. 20 in size, and thoroughly dry.

As the Reclamation Service specification provides that only sound tile shall be accepted, inspection is a comparatively simple matter, as every tile must give a clear ring when struck with a hammer. This is a very positive test, and any piece having a doubtful ring is, nine times out of ten, not a sound pipe. "When in doubt, throw it out," is a very safe maxim to follow in drain-tile inspection, and although the inspector who keeps in mind the serious consequences resulting from a failure of tile in the trench may occasionally reject a sound tile, he need have little trouble with his conscience on that account.



Drain Tile Testing Machine.

Methods of Making Foundation Borings for Dam Sites

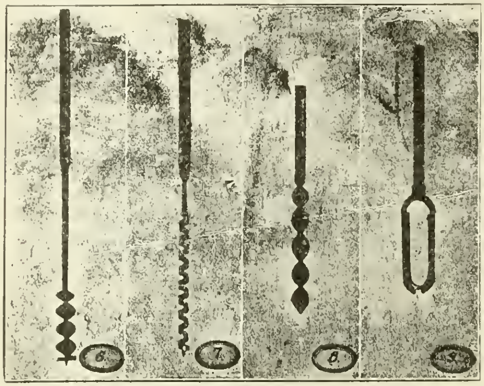
Borings for seven proposed dam sites on the Missouri River in South Dakota were made by methods and equipment which are quite novel and ingenious. They are described in The Wisconsin Engineer by Harold W. Mead. The work was done in connection with a report by Mead & Seastone, Consulting Engineers, Madison, Wis. The following notes are taken from the article.

In the preliminary investigations of the dam sites, it was necessary to make borings to determine sub-soil conditions at each site. Due to the inaccessibility of the sites and the distance that all material had to be carried, the equipment had to be very light and compact. As there was no definite information on making this type of borings, the first part of the work was largely experimental.

The first method attempted was to use 2-in. pipe, driven down to bed rock, as a casing and draw out the material with a 2-in. dirt auger as the casing proceeding. The material that was used for this work was 2-in. pipe cut in 5-ft. sections, ¾-in. pipe cut in 10-ft. sections, a 2-in. dirt auger welded onto one of the sections of ¾-in. pipe, a log chain, a 14-lb. maul, and two pipe wrenches. This apparatus proved practically valueless in this case. We could not find a cap for the 2-in. pipe that would stand the force of driving; so that it was impossible to drive the pipe through the sand and gravel. In the investigation of the Mulehead site, this method was used with some success on the sandbar. For driving caps, 1-ft. sections of 2-in. pipe were filled with lead and threaded at the end to be coupled to the pipe. A 3-in. cap was placed on the upper end and lead run around it so that there was a cushion of lead between the cap and the pipe. A platform consisting of boards laid across two wooden horses 2 ft. high was used in driving the pipe. A depth of 25 ft. was reached with this outfit and the material could be taken from the pipe; but the information given at so shallow a depth was not worth the work involved.

The next method of drilling that was tried was to put the tools down without the casing. This proved more successful and was used in general throughout the investigations. A number of methods were used to sink the tools. When the pipe extended above the ground over 5 or 6 ft., two methods were used. One method was to force the tools down by the weight of a man on the pipe. A wooden handle was bolted on the pipe on which a man would stand while the pipe was held vertical and turned with a pipe wrench. This method was used to the greatest advantage when drilling in clay or shale. The other method was to force the tools down, fastening two long pipe wrenches to the pipe and having a man at each one bear down as they walked around the pipe. This last method was found best for sand and fine gravel. To protect the top of the pipe, driving pieces were made of the regular ¾-in. pipe, cut about 6 or 12 in. long and threaded at one end.

The apparatus that was used to pull the boring tools consisted of a lever, a tripod, and a differential hoist. The use of this apparatus developed from the great difficulty that was experienced when pulling the tools from quicksand and shale. The lever was the first method of pulling that was used It was a piece of 2-in. pipe 10 ft. long reinforced by placing 1½ and 1-in. pipe inside of it. In many cases the lever would not pull the tools, so a 1-ton differential hoist was obtained. The hoist was suspended from a tripod 8 ft. high made of 1½-in. pipe and constructed so that it could be taken down in 4-ft. lengths. The 1-ton hoist was found to be too light and a 2-ton hoist was substituted. In some cases both hoist and lever were used.



Types of Augers: (6) Dirt Augers; (7) Ship Auger; (8) Blacksmith Auger; (9) Post Hole Auger.

A great deal of difficulty resulted from the loss of tools caused by the breaking of the pipe in the ground when considerable depths were reached. One-inch pipe was tried to overcome this difficulty but was not as good as the ¾-in. Finally, extra heavy ¾-in. pipe and extra heavy couplings were tried and were found to be very satisfactory.

For boring in different materials, various kinds of tools were used. Four kinds of augers and two kinds of points were most satisfactory. All were welded onto short pieces of ¾-in. pipe. The augers used were the 2-in. dirt augers, 1 to 2-in. ship augers, 1½ to 2-in. blacksmith augers, and 3-in. post hole augers. The points that were used were both made by a blacksmith from 1½-in. round steel bars and different only in shape. One was pear-shaped and came to a sharp point and the other was chisel-shaped. They were used to drive through any material that could not be penetrated by the augers.

The augers were put down in the holes made by the points and samples obtained. The dirt auger was used to best advantage in clay, soft shale, sand, and fine gravel. The ship auger would bring a sample to the surface even if the hole filled with loose wet material. It was used best through heavy gravel. The blacksmith auger was used in hard shale and soapstone. The post hole auger was used for fine material but could not be used below the water level in fine sand. In quicksand, a ¾-in. pipe was driven to bed rock and enough material would stay in the open end of the pipe.

Borings were made successfully up to a depth of 60 ft. with this apparatus.

Swimming Pools: a New Municipal Enterprise

Wthin the last fews years—since 1910—a new municipal enterprise has come into being in the form of the municipal swimming pool and with it have come new sanitary problems. California, which has 192 swimming pools—138 of them were installed in the period of 1910-18—was one of the first states to enact swimming pool legislation. This act, passed in 1910, gives the State Board of Health general supervision over the sanitation, healthfulness, cleanliness and safety of swimming pools and bath houses. It further provides that no pool or bathhouse can be constructed, enlarged or modified without a specific permit from the Board. Preparatory to issuing regulations the State Board has been making a study of swimming pool design and sanitation. The results of this study are outlined by Mr. C. G. Gillespie, Director, Bureau of Sanitary Engineering of State Board of Health, in a Bulletin of the Board, to which we are indebted for the matter that follows.

Outdoor or Indoor Pool.—In recent years the outdoor swimming pool has increased greatly in popularity. At the present time there are 109 outdoor pools in California and 83 indoor pools. A great impetus was given to construction of outdoor pools in 1916 and 1917, but for obvious reasons there was little activity in any kind of swimming pool construction in 1918.

Some of the finest pools, from an architectural standpoint, are indoor pools, but there is no reason why an outdoor pool can not be made exceedingly ornate and interesting. From a sanitary point of view there is not a great difference in the problems except in the matter of growth of vegetable moss or algae, which in outdoor pools may become exceedingly troublesome if careful provision is not made for its elimination.

Size, Proportions and Main Features of Pools.—The pool should be made as large as can be financed to comfortably accommodate the expected summer holiday crowds, as this is the patronage which is the largest and one most apt to result in breaking down the pool sanitation if it is at all inadequate. In many instances the quantity of water supply available will limit the size of pool. As a rough figure 400 gal. of "pure" or "purified" water per bather is needed. It seems fairly certain that ultimately there must be established by or for each pool a schedule of operation and a limit of patronage which it is known will maintain a prescribed sanitary condition. Hence, if the water supply is limited, it is unwise to make the pool large.

Small town pools appear to require designing for about 100 persons per 1,000 population. The average attendance will of course run much less than this, but the size of pool, quantity of water supply, number of dressing rooms, toilets, showers, bathing suits and towels must be adequate for the maximum patronage.

New pools should by all means be laid out to conform to the sizes and proportions required to make swimming records made in them "official," as this permits featuring competitive water contests, which greatly popularize the establishment. The intercollegiate swimming rules require that the length of pool shall be in multiples of 15 ft. and the width in multiples of 5 ft. The general proportions of the pool should be long and narrow. The length should be from 3 to 4 times the width. Weak swimmers usually swim across the tank while distance swimmers will take the lengthwise course. The long narrow proportion also favors better circulation and freedom from "dead water" in the pool.

If the water supply is limited to, say, 30 gal. per minute or 43,000 gal. in 24 hours, under the best manipulation and without filtration, about 100 bathers could be accommodated and a pool 60 by 20 by 25 ft. would be the largest it is wise to build.

Shape of bottom and depth are important features. For safe diving and to comply with the intercollegiate swimming rules, the minimum depth should be 3 ft. and the maximum at least 8 ft. Water polo requires that 60 ft. of the length of the pool should be 6 ft. or more in depth. For a children's pool the minimum depth of 3 ft. is too great. If the patronage includes children, a small shallow wading pool, possibly attached to the shallow end of the main pool, should be provided. The best shape for the main pool is one which provides a maximum depth at a point just forward of the end of the spring board and a broad area toward the shallow end suitable for general swimming and wading. Most bathers remain in water not over 5 ft. in depth and this portion of the pool floor should have a slope of not over 1 ft. in 15 ft. As the deep end of the pool usually has rather steep slopes, the change from the flat slope to the steep slope should be made at a depth of not less than 5 ft. 6 in. as a protection against inexperienced swimmers slipping if they chance to walk off the flat slope.

Walk drains surrounding the pool should be carefully designed. Material carried in them represents in reality the worst pollution about the pool. It contains suit drippage and a large amount of sputum and effete matter. Designs which provide for a pitch of the walk toward the pool without a raised curb to intercept it carry this filth to the point where bathers are most apt to lounge. Concrete, massive construction or reinforced, is the best material with which to build a pool. Wood or earth in any part of the pool will be positively forbidden. White tile make the best facing for the pool and its walkways. It is impervious and easily cleaned and rough enough to prevent slipping. White cement is often used and is more satisfactory than common cement. In several pools using the common cement finish, an effort has been made to give the pool a sanitary appearance by painting the concrete with a white enamel finish.

The best inlet and outlet arrangement is one which will most quickly permit changing the entire contents of the pool. Nothing could be worse than a single inlet and a single outlet. Experiments show that the bulk of the pool is practically "dead water" when such an arrangement is used. The use of branch inlets about 10 ft. apart at mid-depth, or even staggered in the vertical, along one side, with outlets similarly located on the opposite side, is highly important. Where filtration and recirculation are employed both lines lead toward the filter, but even where the available water supply seems copious it is a wise plan to so lay out the main inlet and main outlet that a filter plant can be later adapted to the pool if it should be desired.

The main drain should be at least 6 in. or 8 in. in diameter and should connect with a sewer or drainway which is known to be large enough to carry the full stream of drainage water.

Water Supply for Swimming Pools.—One of the most important and difficult standards to be set for swimming pools relates to the water supply. Rather than to prescribe a uniform manipulation of the water supply or even to specify the manner of handling it in individual pools, it appears to be wiser, for the purpose of general supervision, to determine physical, bacteriological and perhaps sanitary chemical limits of pollution and to merely suggest a scheme of construction and operation which may be expected to meet the standard.

The main requirements on the water supply are that it can maintain the pool water clean, clear and bacterially safe. It should be clean and clear for clearness' sake and for the ease of aid to a drowning person. It should be bacterially safe for health's safe. There are two distinct modes of meeting these requirements. In some pools they may be combined. The old method, which may be called a "fill and draw" plan, is to empty the pool and refill it with new water every two days to a week, depending upon the patronage, and to add a constant stream of new water between cleanings at a rate which will displace the used water at least once in two days. If this method fails it will be more likely because of the heavy cost of water or because it can not maintain proper bacterial safety and some form of disinfection may be required in addition. The clearness may not deteriorate noticeably with such frequency of change. A pool becomes prohibitively polluted long before it begins to discolor. Clearness is not an index to the bacterial condition of the pool.

The more modern method of handling the water supply, with a view not only to economy but to maintaining a better bacterial condition in the pool, is the rotating or circulating of the pool contents by pumps through filters of adequate capacity, after which it is chlorinated and returned to the pool as "purified" water. It is not uncommon to find that this "purified" water is actually cleaner and safer than the water used in filling the pool. When the available water supply is not sufficient to provide 200 or more gallons of new water per bather, it is believed that filtration and chlorination are imperative.

Pumping equipment and filters should be designed to completely remove and "purify" the entire contents of the pool in the course of one swimming day, or 10 to 14 hours. Our observations show conclusively that unless the water is rotated daily, algae growths are bound to become established. There is little benefit, however, in recirculating or filtering the pool water when there is no swimming going on. The foreign matter tending to accumulate in the pool consists of, first, the floating sputum and scum which are gotten rid of by the splash over the overflow gutters; second, the finely divided discolored matter, bacteria and algae, which permeate the pool and do not settle out readily; third, the heavier and more noticeably visible foreign matter made up of lint from bathing suits, growths of slime, cuticle, dead algae, and the like. This coarser material is in suspension during the day when the pool is patronized and makes a foul appearance, but within a short time after bathing is over it settles to the bottom of the pool. The filter can be effective in removing it only so long as it is in suspension and reaches the outlets. Therefore a filter should be designed and operated to handle the entire pool capacity in from 10 to 14 hours, or one swimming day. In designing it is well to figure on a capacity of 2.0 gal. per square foot of sand surface per minute. Our observations indicate that provision for the use of alum or coagulating chemicals is unnecessary with a swimming pool filter, the reason probably being that the slime in the pool water provides the coagulum naturally. Either open or closed filters appear to yield good results. The former is usually the cheaper, at least in first cost.

Chlorination of swimming pools is apparently highly efficacious. Where it is employed in connection with a circulating system it appears to impart a prolonged disinfecting property to the pool water which is able to cope with the pollution subsequently added as a result of bathing. The explanation of the longer duration of the action in swimming pools than in drinking water supplies may be that the organic matter in the swimming pool forms, with chlorine, the "chloramine compounds" which have been shown to give slower but far more lasting results than the free chlorine itself. Ordinarily, 0.5 lb. of chlorine per 100,000 gal. of water added is sufficient for swimming pool disinfection. The chemical may be added in the form of chlorine gas, in which case a chlorinator apparatus is used, or it may be used in the form of bleaching powder mixed into a solution and fed into the supply at a rate proportionate to the flow. Bleaching powder is weaker than the chlorine gas by about 70 per cent, therefore about three times as much, or 1.5 lb. per 100,000 gal., must be used. Works for the handling of bleaching powder consist of a concrete tank holding about 300 gal. and a small concrete orifice tank for regulating the feed of the solution, besides appurtenant piping. In either case the chemicals may be applied at any point in the circulating system.

Existing pools not equipped with a circulating system may easily provide for disinfection of incoming water by either of these means and largely fortify the pool water against contamination. In pools where the supply of water is particularly low, considerable benefit may also be obtained by splashing the bleaching powder solution evenly over the entire pool just as the bathing stops, so that the wave disturbance may tend to diffuse the chemical throughout the depth of the pool and to disinfect it.

Heating the pool water may be a necessary feature where the new water is very cold and at any event the shower water must be heated quite warm. A temperature in the pool of 64° F. is quite cool while a temperature of 68° F. to 75° F. is comfortable to most people. In the case of a recirculating system, the returned water may be passed through a series of coils over an oil or coal furnace. Some heaters are equipped with steam pipes within a water chamber set in the circulating system.

Student Mock Convention Nominates Hoover for President.—From the national standpoint the most interesting phase of the mock convention held by the students of the University of Minnesota, May 19th, was the possible significance of the outcome. Herbert Hoover was nominated on the fourth ballot, the vote standing as follows:

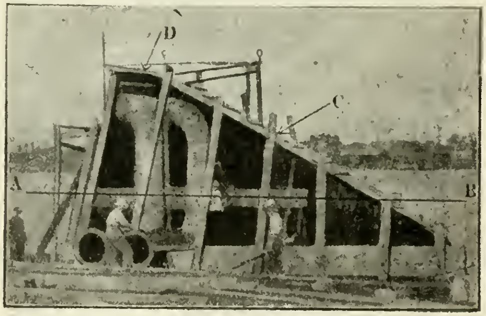
Hoover	256
Bryan	242
Sproul	4

Method of Constructing New Intake at Sarnia, Ontario

A novel intake in the St. Clair River to serve the city of Sarnia, Ont., has been recently completed, and will supplant the infiltration system built in 1914. The basins which formed a part of the infiltration system are used as sedimentation basins for water taken in through the new intake. An interesting description of the intake is contained in an article by F. W. Thorold, Consulting Engineer, Toronto, in a recent issue of The Canadian Engineer. The following is an abstract of this article:

The St. Clair River at the intake, which is within 100 ft. of Lake Huron, has a velocity of over 5 miles per hour. The authorities at Ottawa insisted that we place no obstruction to navigation in the river, and would not allow any structure that would be within 29 ft. of the surface during low water, so any kind of a tower such as used at Buffalo, Niagara Falls, Detroit or Chicago, could not be used. We also had to keep in mind the fact that large steamers might anchor at the head of the river or foot of the lake during heavy storms, and that these ships might drag their anchors directly over our intake structure. A timber crib would make an excellent hold for a ship's anchor, and, therefore, would not make a suitable structure for our intake.

The accompanying illustration shows the general arrangement of this structure. The line AB shows approximately where the ground line of the bottom of the river is, now that the structure is in place in the river bed. This structure is 30 ft. 3 in. long and 16 ft. wide at the bottom, which is its widest part. The "nose" points upstream, and water is taken in at the downstream end. The weight of the completed structure in air was 71 tons, and the displacement is 55 tons.



Side View of Intake Structure, with Pipes in Place.

Great difficulty was experienced in getting contractors to bid on the work. The plans called for the structure being placed in an excavation 47 ft. below water level. The top of the completed structure was to be 32 ft. below water level. We finally induced Dunbar & Sullivan of Detroit to undertake the contract. Their tender for laying the two intake pipes, providing and placing the intake structure, and for placing 200 cu. yd. of one-man stone back in the excavation made for the structure, was $34,000, and strange to say, this part of the work was completed in practically exact accordance with the plans without one single extra.

The length of each intake pipe is 272 ft., and the minimum covering over the pipes is about 3 ft.

The original plans called for building the intake structure on the shore, with concrete walls 1 ft. thick, towing it into position and sinking it in the river, and then filling it with concrete from scows. But the largest derrick owned by Dunbar & Sullivan could lift only 25 tons; therefore, that firm asked us to revise the plans so that the weight of the structure built on shore would not exceed that amount.

A 10 by 10-in. timber foundation was first built on shore to conform to the shape of the bottom of the structure. These timbers were well bolted together, and were covered with 2-in. planks and then with 1-in. T. & G. boards. The forms were built nearly water-tight. One toot of concrete was placed on the timber foundation inside the form before it was lifted onto the scow. Concrete was also placed in the "nose" of the structure for a distance of 6 ft. back from the "nose." A 10-in. nipple was placed in the form at the point marked C, and another at the point marked D. These were capped. A flexible joint and one length of steel pipe was attached to the pipes from the inside of the structure. Three lifting bolts, securely fastened into the concrete base, were also placed.

The river-bed excavation for this structure was made with a clam, and after very little trouble good progress was made. Fortunately, the work was in fairly hard material, and there was no difficulty with the excavation "filling up." The work had once to be abandoned on account of a heavy blow down the lake, but the excavation did not fill to any appreciable extent.

When measurements taken over the excavation showed that it was at the proper depth, and when the weather was favorable, the scow—with the structure on it and with the lengths of pipe attached was towed into position and securely anchored in the river. The structure itself was lifted by a cable attached to one drum on the derrick, and the pipes by a cable attached to another drum, so perfect control was obtained.

The structure was lifted at 1 p. m., Monday, Aug. 11, 1919. It took so long to sink that thoughts of having to fill it with water flashed through the minds of the engineers. However, by lowering very gently and giving it time to fill, everything proved to be entirely satisfactory. At 4 p. m. the structure was in its exact position, and measurements taken at various places showed it to be resting level and pointing correctly upstream.

The following morning an 8-in. pipe was placed in the lower hole, marked C, the upper end of this pipe being at the side of the scow. At 11 a. m., 20 bags of neat cement, in the form of a thick grout, were poured into the 8-in. pipe. This 8-in. pipe rested on the concrete floor inside the structure. When the pipe was filled, it was lifted a little and the concrete slid into the structure. The concrete reached the top of the hole C at 5 p. m. The diver then made his inspection and reported the crib full to within 1 ft. of the form at that point. It took until 9 p. m. to have the pipe changed to hole D, and until 6 a. m., Wednesday morning, to fill the structure with concrete up to hole D. Later that same day 200 cu. yd. of large stone were dumped in the river upstream from the structure; the clam lifted these and placed them around the structure to fill the excavation previously made. Excavation was then made for the intake pipes, and they were laid and connected to the intake structure without great trouble. The current at the bottom was so great that the diver had to be tied to a cable anchored in the river at one end and to the scow at the other.

The intake has been in continuous use since last November.

Personals

R. T. Campbell has been appointed city engineer of Brainerd, Minn.

Chenoweth & Rettinghouse, civil and consulting engineers, have opened offices at 215 Boyce-Greeley Bldg., Sioux Falls, S. D.

Douglas Sprague and Chester A. Slocum, associate consulting engineers, have moved their offices to 167 West 13th St., New York City.

John Boswell Whitehead, professor of electrical engineering at Johns Hopkins University, has been appointed to the new office of dean of the department of engineering.

J. C. Wooley, professor of agricultural engineering at the University of Idaho, has been appointed to a similar position at the University of Missouri, succeeding E. W. Lehman, who has resigned.

Joseph A. Martin, heretofore commissioner of the Department of Purchases and Supplies of Detroit, Mich., has been appointed Commissioner of Public Works, succeeding George Engel, who resigned to devote his time to private business interests.

Wm. P. Butler has resigned as senior highway engineer, U. S. Bureau of Public Roads, to become associated with the Southern Surety Co. as consulting engineer. His duties will be to pass on all highway risks for the surety company from an engineering standpoint; to keep in close touch with the progress of all work for which the company is surety; to assist all contractors bonded by the company in every manner possible in their work; to try to create a better feeling between the state highway departments, the contractors and the surety companies; to relet or complete by day labor any contracts turned back on the company for completion, and to try to anticipate trouble before it arrives and reduce to a minimum the chances of a contractor-client "going broke."

Obituaries

Claude Parmer, vice-president of the Kuest Contracting Co., Indianapolis, Ind., was killed recently by a fall from a bridge which he was erecting at Cincinnati, O. He was 34 years old.

William M. Browo, chief engineer of the Passaic Valley Sewerage Commissioners, died suddenly May 29. He was 68 years old.

I. N. Bramhall, a contractor of Tekamah, Neb., was killed June 1 by a train. He was 75 years old.

Railways and Excavation Monthly Issue

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Roads and Streets—1st Wednesday
(a) Roads
(b) Streets
(c) Street Cleaning
(d) Municipal Miscellanies
(e) Management and Office System

Waterworks and Hydraulics—2nd Wednesday
(a) Waterworks
(b) Sewers and Sanitation
(c) Irrigation and Drainage
(d) Power and Pumping
(e) Management and Office System

Railways and Excavation—3rd Wednesday
(a) Excavation
(b) Management and Office System
(c) Quarries and Pits
(d) Steam Railways, Construction and Maintenance
(e) Electric Railway Construction and Maintanance

Buildings and Structures—4th Wednesday
(a) Buildings
(b) Bridges
(c) Harbor Structures
(d) Miscellaneous Structures
(e) Properties of Materials
(f) Management and Office System

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Are Railway and Public Utility Companies Entitled to Dividends Upon "Unearned Increments" in Value?

State public utility commissions are apparently all in accord on one point relative to rate regulation, namely, that the value of a public utility plant should not be based upon "present abnormal prices." For example, the Missouri Public Service Commission recently ruled as follows:

> The commission is without inclination in this case to accept present-day unit prices upon applicant's property, believing the proffered enhanced value thereof to be an unearned increment, and upon which the consumers should not be required to pay an investment return.

Note the use of the expression "unearned increment." This is one of those question-begging terms that are intended to serve the place of argument. If an increment in property values is unearned, it seems to follow that the owner of the property has no moral title to the increment. Hence the persuasive power of the expression "unearned increment." But a careful thinker will always look behind the screen of words that are so often used to conceal the facts. In this case the facts are that a dollar today will buy less than half what it would buy five years ago. Hence if an investor in public utility company stock made his investment more than five years ago, and at that time received 6 per cent annually thereon, and if today the same investor is permitted to receive only 6 per cent, he has been deprived of more than half his real income. But if his property is valued at double the investment cost, and if he is allowed to earn 6 per cent on this increased value, he is given nearly the same real income that he had prior to the war.

Real income (as distinguished from money income) is measured in commodities and services. It is unfortunate that public utility commissioners still remain reluctant to grant that an investor is entitled to have his real income maintained at the prewar level. The very same commissioners never deny that right to wage-earners, but when it comes to investors in public utility plants they persist in talking in terms of dollars rather than in terms of the things that dollars buy. Expressed in terms of the things that dollars buy, there is not a cent of unearned increment in a plant that is today valued at double its prewar cost.

The expression "unearned increment" has a question begging twin namely "normal value" that is very popular at present. We quote from the recent language of Justice Hughes in the Brooklyn Borough Gas Co. case:

> This question of taking the hypothetical reproduction cost under abnormal conditions as a rate base should, of course, not be confused with the necessity of recognizing actual costs of operation even though abnormal. A public service corporation is entitled to be reasonably compensated for its service, and the actual cost of its operation must always be taken into consideration in determining whether or not it receives a fair compensation above that cost. But it is a different thing, after cost has been defrayed, and the question is as to the compensation to be allowed in excess of cost, to take as the basis for a compensatory return an asserted plant value, far above the actual investment, which is reached merely by expert estimates of a cost of reproduction under abnormal conditions. This would result in allowing a public service corporation to take advantage of a public calamity by increasing its rates above what would be a liberal return not only on actual investment, but upon a normal reproduction cost, in the view that unless it could make an essentially exorbitant demand upon the public it would be deprived of its property without due process of law. The enforcement of the constitutional guaranty does not require the application of any artificial formula. It has constantly been pointed out that the rate base must be what is called "the fair value of the property," and that as to this there must be a reasonable judgment based on a proper consideration of all relevant facts.

Note the sophistry that occurs in the use of the words "normal" and "abnormal." "Abnormal" construction costs are here spoken of as if they were necessarily "ephemeral"—something like a tornado, present for a few moments and then gone.

Note also the absence of any attempt to define "normal" prices. The Missouri Commission gives the following very loose definition of "normal prices":

> The former (increased operating expenses) after close scrutiny, and in many instances, material adjustments, the commission has felt constrained to allow, but the latter (increased construction costs) the commission has steadfastly refused to grant; the commission holding to the view that the equities of the situation controlling are of such a nature that the consuming public should only be required to contribute an investment return upon the value of the utility bottomed upon an average unit price covering normal periods of from one to ten years antedating the present abnormal economic conditions covered by the great war, and when available, current unit prices prevailing at date of construction. Supplementary to this, however, the commission has uniformly permitted invoice prices of new construction, replacement and betterments, when prudently made during this abnormal price period.

We have here a statement that "an average unit price covering normal periods of from one to ten years antedating the present abnormal conditions" would be regarded as a "normal unit price." But this very definition is question begging, for it defines a normal price by calling it an average price over a "normal period." Now the fact is that a "normal period" is one period for one man and another for another man. It can not be defined except arbitrarily. Thus it might be defined as a period during which annual average prices of commodities do not vary more than 20 per cent, or some other arbitrarily assumed percentage. To define a "normal period" so as to make it necessarily a prewar period is obviously unjustified by any ordinary use of the term "normal."

Two years after our civil war ended, conditions became about as "normal" as they had ever been. Yet from 1867 to 1871 inclusive, average commodity prices were 35 per cent above the average of the year 1860, and building material prices were 62 per cent above the level of the year 1860. Had public utility commissions existed at that time would they have called the period of 1867 to 1871 "abnormal"? If so, when did there occur a "normal period" between the year 1871 and 1896? Economic conditions were constantly changing, and so were average prices of commodities. The wholesale index price of commodities was 112 in 1871, and it dropped quite uniformly for 25 years, reaching 67 in 1896. Then the tide turned and prices rose steadily for 16 years, reaching 100 in 1913.

Commodity price levels have ranged from an average of 67 in 1896 to 214 in 1919, and now the level is about 250. Who can tell what is "normal" about a phenomenon whose very essence is to change through such an enormous range during a comparatively short time?

The plain truth is that when public utility commissions use such expressions as "normal conditions" and "normal prices," they use terms that have a purely arbitrary meaning attached to them. In one breath they concede to the employes of a utility company the right to have "abnormal" wages, and in the next breath they deny to a stockholder the right to have an "abnormal" income. In short, they grant the justice of giving the wage earner an adequate real income (as distinguished from a money income), but they refuse to mete out the same justice to a stockholder. It is this persisting attitude of niggardliness and even injustice toward investors that has brought nearly all American utility and railway companies to the verge of ruin. This accounts largely for the underbuilt, underequipped condition of our railways, and the consequent economic loss that the entire country is now facing.

"When Doctors Disagree"

"Confidentially, the more we study H. C. L., the less we seem to know about it. What can be expected of a poor earth-mover, anyhow, when doctors disagree?" Thus speaks the editor of The Earth Mover in the closing paragraph of an editorial which we reprint on another page.

Answering this question, which is one that perplexes many a man today, we would suggest that there is an easy method of testing, in some measure, the reliability of any diagnosis made by any "doctor" who is prescribing a remedy for a disease of the body politic. The test is this: Require the "doctor" to prove that he has spent fully 60 days gathering and analyzing all the available data. Then follow up this test by another, namely, that his qualitative theories and conclusions be expressed quantitatively.

If a physician were to tell you that a certain treatment of a disease would undoubtedly effect a cure, you would be justified in asking him to show you data indicating what percentage of cures have been effected by that treatment. If, instead of showing you a sufficient quantity of such data, the physician were to reply that you must rely upon his assertion, you would be inclined to doubt whether he had any quantitative proof of his statement that the proposed treatment is usually efficacious. Similarly if a political economist says that "we shall reduce the cost of living only when we can reduce these increased costs of production," you are justified in demanding that he produce quantitative evidence that prices invariably rise or fall only in proportion to and in advance of the rise or fall of the costs of production. If he can not produce data to show this relationship between prices and costs, you may well doubt his assertion.

We are too much inclined to despair of arriving at a correct conclusion on a given subject, when two or more specialists in that subject disagree. We reason that if specialists disagree, it will be futile for a non-specialist to judge their respective arguments and facts. There are, however, various simple ways of measuring the probable reliability of specialists. The most common way is to compare their relative experience. A specialist of long experience in a given field is apt to be more reliable than one of short experience. But it should be remembered that even a seemingly narrow field of specialization may actually have a great many subdivisions, each of which requires a deal of study if mastery of it is to be secured. Thus to be a civil engineer is to be a specialist, but to be a railway engineer is to be a greater specialist, to be a railway appraisal engineer is to be a still greater specialist. Even the last named specialist may specialize in one of several branches of railway valuation, as, for example, grading, track, bridges, etc. Bearing this in mind, it is apparent that a young assistant engineer who has spent, say, a year analyzing and estimating the cost of railway bridges may know much more about bridge costs than the chief engineer of a railway who boasts of forty years' experience in location and construction.

So, when judging the relative reliability of specialists, the layman should always investigate the amount of time that the specialist has devoted to the particular, narrow subject upon which he is presumed to have special knowledge. But the investigation should not end with an inquiry as to the amount of time spent by the specialist on a given subject. Attempt should be made to ascertain the thoroughness with which he has applied himself to that subject. This can usually be ascertained, either by inquiry among his close acquaintances, or by an examination of what he has written or said upon the subject. Anyone who has seen a clever attorney expose the ignorance of a specialist by a searching cross-examination, need not be told that a layman can ascertain with considerable accuracy the reliability of any one who is regarded as an authority.

It may be replied that such an inquiry as we have suggested is not always possible. How then is a layman to discriminate between disagreeing doctors and select the most reliable? There remains then only their respective statements by which to judge, but even those statements may suffice. The specialist who fails to justify his conclusions by a careful and complete analysis of the facts that have led him to the conclusion is usually less trustworthy than the specialist who discloses the logical process by which he has made his inferences. The judge who renders a verdict in an appraisal or rate case without stating his reasons is ordinarily a weak judge. He is fearful that the reasons will be seen to be incorrect and his decision reversed by a higher court.

As between two specialists, one of whom backs up all his conclusions by quantitative data, while the other cites only authorities, precedents and theories, choose the former, provided his data are not shown to be untrustworthy. As between the engineer who produces a detailed record of the cost of laying a thousand miles of track under stated conditions, and the engineer who produces no records, it is safer to rely upon the former. Similarly, if one political economist produces records of the rise and fall of commodity prices covering many war and postwar periods, whereas another economist produces no such records yet maintains a different conclusion as to the causes of price changes, choose the economist who has the data.

There is ordinarily not a great difference in the native ability of two intelligent men, and there is ordinarily little difference in their ability to weigh evidence, but there is apt to be a marked difference in their respective diligence in gathering evidence. Hence the man who gives proof of having shown superior diligence in searching for facts is usually more reliable than the man who tries to reach conclusions without going through the labor of delving for data.

"Fluctuating Valuation Has Nothing to Recommend It"

Carl D. Jackson, Chairman Railroad Commission of Wisconsin, in a recent address said:

> The conception of fair value has assumed increased importance recently because of the great and rapid change in all unit construction costs. Undue emphasis on value without considering the investment will unquestionably tend to establish fluctuating values or rate-making bases, which ought to be stabilized. The assignment of constantly fluctuating value to property devoted to a public use has nothing to recommend it. A rule which tends to protect public utility investments when prices are declining must recognize investment when costs are inflated.

The evident inference from this statement is that property value for rate-making purposes should be investment cost and not cost of reproduction at present prices. The latter would result in a "fluctuating value" which Mr. Jackson believes has "nothing to recommend it."

A dollar that fluctuates in purchasing power certainly has nothing to recommend it. As far back as 1851, A. B. Johnson in Hunt's Merchant's Magazine for March, urged the importance of stabilizing the dollar. He said:

> Government might measurably shield creditors from such a danger, by statedly increasing the quantity of gold which composes an eagle; so as to compensate in quantity from time to time as depreciation of value should become certain and permanent; as the British Government, some years since, called in the guineas which had lost weight by abrasion. Such a process would prevent the currency from sustaining any great loss of value at any one time; and would also confine the loss of the holders of the coin for the time being, without entailing it, and accumulating it, on remote debts. But governments are usually debtors themselves, and will not be likely to enhance their own burdens.

Irving Fisher, professor of political economics at Yale, has been urging the adoption of a plan similar to that proposed by Mr. Johnson nearly 70 years ago. The object of thus stabilizing the dollar is to prevent marked fluctuations in the average prices of commodities. If this had been accomplished, say, 10 years ago, a dollar invested then in a bond would still have the same purchasing power and the 5 ct. annually earned as interest would still buy, on the average, as much as it would then buy. But since the dollar has a fluctuating value, an investment in bonds made 10 years ago yields an annual income now that will buy only 40 per cent what it would buy in 1910.

Prof. Jackson urges "stabilized values," but note that he is not speaking of stabilizing the value of the dollar, nor the value of a day's labor, nor any other value than that of a public utility. But consider the real effect of this alleged stabilizing of the value of investments in public utility plants. So far as the prewar investors are concerned, this alleged stabilization of their values is exactly the opposite of stabilization; to stabilize a value is to maintain a constant ratio of exchange, and there has been no such constancy nor does Prof. Jackson propose that there shall be. On the contrary, he proposes that the dollar invested in a public utility before the war shall be so unstable in its value (or exchange ratio) that while this month it may buy 40 ct. worth of commodities at prewar prices, next month it may buy 30 ct. worth or 50 ct. worth, or whatever the fluctuating index price of commodities may make the dollar worth.

As opposed this plan of alleged stabilization of investments in public utilities, Prof. Fisher recently advocated before the Public Utility Commission of Pennsylvania a plan that would lead to real stablization. He said that if the net earnings on a utility plant investment were fair before the war, those net earnings should be multiplied by the present index price, or about 2.5. to make them fair now. In effect, he said that the plant investment should be multiplied by a factor found by dividing the wholesale price index at the present time by the index at the time of the investment. If this were not done the value of the investment might be constant as expressed in dollars, but it would be fluctuating as expressed in commodities.

Since men make investments for the purpose of deriving a money income that can be converted into a commodity income, it appears to us that Prof. Fisher's plan of stabilizing public utility investments would accomplish its purpose, whereas Mr. Jackson's plan of stabilization would actually perpetuate instability. An approximate accomplishment of Prof. Fisher's plan is bad when a plant is valued at its present cost of reproduction. It so happens also that the U. S. Supreme Court has approved valuations based on present unit prices, and has expressly disapproved of valuations based on investment costs.

Will Production in 1920 Equal That of 1919?

To the Editor: This is an interesting question. The production of commodities of all kinds may be measured roughly by bank clearings divided by index price (1913 being taken as base or 100). So estimated the production in last few years has been as follows: 1912, 174; 1913, 169; 1914, 155; 1915, 187; 1916, 208; 1917, 175; 1918, 166; 1919, 196.

Now what is 1920 likely to be? The index price this year is 15 per cent above last year or is now 244. Bank clearings to May 1 have been 155 billions, which divided by 2.44 gives 63. For the last 8 months of last year clearings were 300 billions. If they are the same this year during the same period that figure divided by 2.44 gives 136 which added to the above 63 gives 199 as the figure representing production of commodities for the year 1920.

Plotting the production for each year it is seen that the production rises and falls in waves or cycles, 1912 being a high point and also 1916, and taking other years back of 1912 the same thing appears, according to this either 1919 or 1920 will be a high year and 1921 and 1922 lower. As further indicating the near future it may be observed that sales of shares of stock fluctuate and that their fluctuations are generally followed a month later by clearings. Stock sales fell off in April as compared with March, therefore May clearings may be expected to be less than April and so far this month that is proving true. The first two weeks of May stock sales are less than for same period in April forecasting a further reduction in June. So that clearings for the rest of the years may be less than for the same period last year. JOHN WILKES.

Nashville, Tenn.

Cost of Levee Construction in Louisana

The earth utilized in building the levees of Louisiana, by the Levee Districts, and the State, during the past two years, has continued to be moved mostly by power-driven machinery, the latter still standing first in place of volume of work performed; that performed by scrapers drawn by mules, second, and by men with wheel-barrows, third. The percentages, according to the recently issued report of the Board of State Engineers, were as follows:

By power-driven machinery, 65 per cent; by scrapers drawn by mules, 30 per cent; and by men with wheel-barrows, 5 per cent.

The average cost of the levee work performed by the Levee Districts and the State, by all methods, during the past two years, was 30.00 ct. per cubic yard; and by the three methods named, as follows:

By power-driven machinery, 21.50 ct. per cubic yard; by scrapers drawn by mules, 46.00 ct. per cubic yard, and by men with wheel-barrows, 31.05 ct. per cubic yard.

Chamber of Commerce of U. S. Not in Favor of Federal Department of Public Works.—A proposal that the Chamber of Commerce of the United States advocate the establishment of a government Department of Public Works failed to carry in a referendum of the Chamber's membership, the result of which was announced June 6. The votes on the three propositions submitted were: Shall a Department of Public Works be established by the national Government? In favor, 826; against, 549; necessary to carry, 917. Shall a Department of Public Works be established by a suitable modification of the existing Department of Interior, excluding therefrom the non-related bureaus and offices by change of name from the Department of Interior to the Department of Public Works? In favor, 675; against, 679. Shall a Department of Public Works be established by creation of an entirely new department? In favor, 282; against, 992.

Pressure Cells in Miami Conservancy Dams Show State of Solidification of Core Material

The pressure cells (see Engineering and Contracting, Nov. 19, 1919) installed by the Miami Conservancy District to determine the degree of solidification of the hydraulic fill cores of the dams now being built by the District, have proved very useful in indicating the condition of the core materials. The conservancy dams, by the way, are the first in which such cells have ever been applied for such a purpose. Interesting information on the results obtained from the use of these cells is given in the March issue of the Miami Conservancy Bulletin, from which the matter following is abstracted.

The method of installation of the cells has depended on the type of dam outlet structure. At Lockington, Taylorsville and Huffman, the outlets are carried between heavy retaining walls (the side walls of the spillway), which extend entirely through the earth embankment and up to its full height. At these dams the cells are supported on the back faces of these walls. At Germantown, and Englewood, where the spillway is a separate structure, and no such walls exist, the plan provides for supporting the cells on light wooden towers. At Germantown, there are three towers, one near the center line of the dam core, and one near each of its two faces. These towers are built up section by section as the material in the dam rises during construction. The pipes carrying the air pressure to the cells are suspended vertically from the tops of these towers, with an earth pressure cell at the bottom of each pipe. For the lateral pressures, cells are suspended at intervals of 10 ft. in depth, as the dam rises; for vertical pressures this interval is 30 ft., experience showing that the lateral (horizontal) pressures are the ones needing most careful watch. The compressed air tank, air gage, etc., are carried on a platform at the top of the tower. To permit a pressure cell to settle with the material in the core (as the mud in the bottom of the pool is consolidated by the steadily increasing pressure of the added material), each cell with its ascending air pipe is suspended by a wire running over a pulley at the top of the tower, the other end of the wire carrying a counterweight. The air tank and air gage are successively connected to the top of each pipe by a rubber hose and a valve, precisely in the manner of connecting an automobile tire to the air tank in a garage. Thus the pressure measurements for all the cells are rapidly and easily taken. Observations are made at monthly intervals.

For study and comparison the measurements are plotted on diagrams. The upper row of rectangles in Fig. 1 is a series of such diagrams for the cells at the tower near the dam center line at Germantown, the lower row of rectangles showing conditions at the tower in the gravel slope near the down-stream edge of the core pool. Each rectangle gives the results of one full set of the monthly observations, the date being noted above the rectangle. Setting the diagrams thus side by side, the behavior of the dam core material, month by month, can be readily studied.

Each small circle and small triangle indicates a measurement on a pressure cell; the circle a horizontal pressure, the triangle a verticle pressure. The amount of the pressure is given by the distance of the circle or triangle from the left edge of the rectangle it is in, the successive vertical lines marking successive increments of 5 lb. pressure, as indicated by the figures 5, 10, etc., below the rectangle. The distance of the circle or triangle from the bottom of the rectangle indicates the distance of the measuring cell from the bottom of the dam, the successive horizontal lines marking 10-ft. vertical intervals. (The figures at the left edge of the left diagrams give the elevation of these lines above sea level—720,730, etc.) Thus the upper small circle in the left upper rectangle indicates that on Sept. 10, 1919, there was a horizontal pressure of about 2 lb. per square inch in a cell on the center line tower 730 ft. above sea level, or 4.5 ft. below the level of the water in the core pool, the latter being given by the short horizontal line on the same diagram marked "W. S." (Short horizontal lines marked "S. S." and "G. S." indicate respectively the level of the silt surface and the gravel surface at the bottom of the core pool). Near the bottom of the upper left rectangle the small circle and the small triangle practically coincide, showing that at the depth in the pool indicated, about 12 ft., the vertical and horizontal pressures were the same (about 6 lb. per square inch). This means that the mud at this point was still so thin that it behaved as a liquid slightly heavier than water.

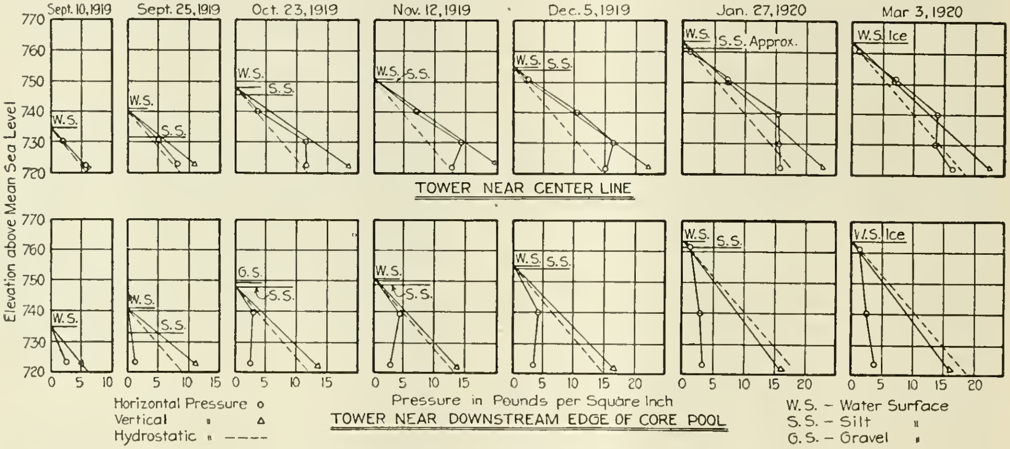


Fig. 1—Diagrams of Earth Pressures, Germantown Dam.

The next rectangle in the upper row shows the condition at this tower on Sept. 25, 15 days later. The water surface in the pool has risen to elevation 740.5. "S. S.," the silt surface, indicates that a distinct surface of mud at the pool bottom has formed about 9 ft. below the water surface. The little triangle indicates a vertical pressure of about 11 lb. at a depth of about 18 ft. in the pool, and the lower small circle indicates a lateral pressure of about 8 lb. at the same depth The difference of 3 lb. indicates a stiffening of the mud at this depth, since if the mud were still thin enough to act as a liquid, the two pressures, lateral and vertical, would be equal.

The lowest circle and triangle in the next rectangle, showing the conditions a month later. Oct. 23, shows a marked and significant change in the core material. The lowest circle is directly below the next lowest, indicating that the additional depth of core deposited during this month, about 7 ft., has not made any addition to the horizontal pressure in the core material at the lowest pressure cell. At the same time the vertical pressure, at the same point, given by the little triangle, has risen from 11 to 18 lb. The difference between the horizontal and vertical pressures at this point, the measure of the solidification of the materials, has risen there to about 6½ lb. (Indicated by the horizontal distance between the lowest circle and the lowest triangle). This fits with the significant fact above noted, that the increase in depth of material has not increased the horizontal pressure at the bottom of the dam (the level of the lowest small circle and small triangle readings). All the later diagrams tell a similar story that below a depth of 20 to 25 ft., the horizontal pressure remains constant, although the depth of core material is steadily increasing, while at the same time the vertical pressure increases. Analysis would seem to indicate that this means a sufficient stiffening of the core material such that if a cube of it were cut, several feet high, it would stand alone. Explorations are in progress to ascertain by examination of the actual materials, whether this is the true state of affairs. If so, it will constitute an additional assurance in this important matter. In any case, there can be no doubt that the pressure cells have already proved their value in action and have indicated a condition of the core materials which is very satisfactory to the engineers in charge.

This is no less true of the materials in the sand and gravel retaining embankments, between which the core lies, as may be seen by an inspection of the lower row of rectangles, showing the conditions just outside the pool margin, where pressure cells have been imbedded in these materials. These embankments, as has been said, give weight and stability to the dam structure. They also, by their open, porous texture, permit free drainage of the water which slowly escapes sidewise and downward from the core. This is an important function, and the lower diagrams show that the porous materials are performing it in a highly satisfactory manner. The small circles show that the horizontal pressure at the bottom of the dam, in these materials, never exceeds 3½ lb., although the water pressure alone, at the depth reached by the material in the last two diagrams, would be about 19½ lb., if the water were confined. At the same time, the vertical pressure, as indicated by the small triangle, is being transmitted up to 16 lb. intensity. The desired porosity and stability of the sand and gravel next the impervious core are thus indicated.

7x10 Ft. Drift Driven at Rate of 6 Ft. Per 8-Hour Shift

A 7-ft. x 12-ft. drift at the Harmony Mines at Mineville, N. Y., was driven recently through hard gneiss rock a distance of 213 ft. in 36 8-hour shifts. The gang per shift consisted of two machine men and three men mucking and tramming. No. 248 Ingersoll-Leyner drills with 1¼-in. round hollow drill steel with crossbits and ¼-in. change were used. The gage of the starter bit is 2¼ in., four changes were made, and the holes drilled according to the V-type cut system. Time fuses, No. 8 caps, and Du Pont gelatin were utilized in blasting. The two machine men drilled, loaded, and fired 26 9-ft. holes per shift, which is 234 ft. of drilling per round. The muckers loaded the dirt in 1½-ton cars and pushed them to the main slope. The following figures on the work are taken from the Engineering and Mining Journal:

Size of drift	7 ft. x 12 ft.
Holes drilled per round	26
Number of feet drilled per round	234
Number of men per shift	5
Advance of heading per shift	5 92 ft.
Advance of heading per man per month	31 93 ft.
Cu. ft. rock removed per man per shift	99.46

Oklahoma State Organization of Am. Soc. C. E.—In connection with the summer meeting of the Oklahoma Society of Engineers last week, the Oklahoma members of the American Society of Civil Engineers perfected a state organization with the following officers: President, H. V. Hinckley, Consulting Engineer, Oklahoma City; Vice-Presidents, E. S. Alderman, Federal Road Engineer, Oklahoma City; C. M. Pritchard, Consulting Engineer, Tulsa; E. M. Graham, Consulting Engineer, Muskogee; F. D. Brown, City Engineer, Shawnee; H. F. Layton, Empire Gas Co., Bartlesville; Max L. Cunningham, Municipal Construction Co., Oklahoma City; Secretary, F. H. Craddock (Musson & Gayle), Oklahoma City. It was voted that June and October meetings be held in connection with the conventions of the Oklahoma Society of Engineers and that wherever A. A. E. chapters exist, the fullest affiliation shall be in order.

Levee Settlement: Causes and Remedies

For several years the Board of State Engineers of Louisiana has been studying the causes of levee subsidence. In their biennial report under date of April 20, 1918, certain conclusions (see Engineering and Contracting, Aug. 21, 1918). that had been reached at that time were given. Further particulars of the investigation are given in the recently issued biennial report covering the period from April 20, 1918, to April 20, 1920. The notes following are taken from this report.

During the past two years levee subsidence that necessitated special consideration developed at a number of localities. The principal localities and the methods of treatment were as follows:

Panther Forest Emergency Loop, in Chicot County, Arkansas.—This levee, built under the direction of the U. S. Engineers, during February and March, 1920, was necessitated by a cave in the Panther Forest Revetment. The new loop is located on the edge of an old lake, on a foundation composed mostly of soft mucky material. The levee has an average height of 20 ft., with an 8-ft. crown, and 3 and 3 to 1 slopes.

When the embankment was completed to within 8 ft. of grade, it began to subside, and although the force continued to work for a week adding sufficient material to complete the levee to the prescribed height and dimensions, it continued to subside, coming to rest gradually at practically the same elevation at which movement was first noticed.

As the levee was constructed with a view of securing protection from the high water of 1920, it was decided to suspend work on the embankment as far as it had progressed, converting it into a banquette, and building up a new section along the river side thereof where the foundation appeared to be firmer. The work is now completed, and neither in the later course of construction nor since has there been any evidence of further sinking, or instability.

Carmichael Levee, in Chicot County, Arkansas.—The location extends along the edge of an old lake bed, or swamp. The foundation upon which the levee rests is made up of the deposits successively brought down by each high stage of the Mississippi River, and is composed mostly of sand and a loose loamy soil.

In August, 1916, the Tensas Basin Levee District let a contract for improving 1900 lin. ft. of the line. This consisted of cutting off the top of the old levee to form a banquette, and placing an enlargement on the river side, with 8-ft. crown and 3 and 3 to 1 slopes.

In October, 1917, when the work was practically completed, the embankment began to subside at the lower end, for a length of 575 ft., and within three days after the first movement was noticed, it had gone down about 5 ft. There was no evidence of the earth being disturbed on either the river or land side of the levee; but it was noticed that the pressure was forcing water up in the pits about 100 ft. to the river side of the levee.

It seemed apparent that the cause of the subsidence was due to the heavy weight of the embankment placed in the enlargement breaking through the surface crust causing an outward movement of the soft material generally found underneath an alluvial bottom.

The levee was treated by rebuilding the embankment in shallow layers, and as the work was in the course of construction, subsidence continued, evidence of which was shown by the berm rising as much as 12 ft. above the natural surface of the ground for a distance of 200 ft. beyond the toe of slope.

After completion, some slight movement in the embankment continued, the latter subsiding in the course of two years from 1 to 2 ft.

The embankment is now being rebuilt, with a false berm, constructed on the river side to a height of 8 ft. below the grade of the levee, 60 ft. crown and 3 to 1 slopes.

In September, 1918, a year after the enlargement was first apparently completed, a second subsidence occurred, about 500 ft. up-stream from the first movement, where 300 ft. of the levee sank from 3 to 7 ft. The action of the subsidence was in every way similar to that described as occurring in the first subsidence. The levee was rebuilt three times, but would not remain up to grade. It is now under contract to be rebuilt to required grade and section with a false berm on the river side to a height 8 ft. below grade, with 60 ft. crown and 3 to 1 slopes.

Hard Times-Wilson Dyke, in Tensas Parish.—This was built by the U. S. Government in 1883-1884 across the head of Lake St. Joseph, on a foundation composed of a sandy loam, resting on the soft bed of the lake. The line of levee there is at this time under government contract for enlargement, requiring the cutting down of the old levee to form a banquette, and an enlargement on the river side thereof.

During the latter part of October, 1919, when the enlargement was practically completed, the latter and part of the old levee subsided for a length of about 1,000 ft., to an elevation below that of the banquette.

The material was placed in position with a drag-line machine, leaving a berm 40 ft. wide and limiting the pit to a side slope next to the levee of 1 on 2 down to a depth of 3 ft., from which point out a slope of 1 on 50, was prescribed. There was no evidence of any upheaval in the pits, or any disturbance of the ground on the land side at the time the subsidence first occurred; but after material was added to the levee, there were indications of some movement in the berm, manifested by large cracks and changes in the elevation.

The opinion is entertained that underlying the foundation of this levee is a stratum of semi-fluid material which was displaced when the weight of the enlargement broke through the surface crust, causing an outward movement of the soft material with the solid soil taking its place. A team force with wagons is now (April, 1920) engaged attempting to rebuild the embankment by dumping earth over the subsided portions, but, as yet, no material progress has been made in bringing the levee up to the required height. As fast as the embankment is built up 2 or 3 ft. it again subsides.

It is believed that as soon as the river falls sufficiently, the pits on the river side of the line should be refilled, a false berm of sufficent height and dimensions to act as a counterweight for the levee added, gradually building up the levee proper until a stable condition at the required height and section be established.

Lacour Levee, in the Parish of Point Coupee, Mississippi River, Right Bank.—Here the United States had recently enlarged the then maintaining line of levee, by partially cutting down the old levee to form a banquette to river side enlargement. The enlargement slid or sloughed away from the banquette, or remaining portion of the old levee, out on to and over the berme and into the borrow pits.

It seemed apparent that the sliding or sloughing was directly due to the presence of a narrow berm and deep pits. The character of the soil in the vicinity is, for a depth of 8 to 10 ft., mostly what is known as "buckshot" earth, below which a stratum of blue sandy muck is encountered. The foundation being soft and yielding did not sustain the added weight, sloughing out at the base, and causing the new section to subside from 8 to 10 ft., below the established grade line

To cure this condition, the sliding or sloughing portions were cut out and the material so moved loaded upon the pits directly in front of the movement. Then, in advance of the restoration of the section cut away, a false berm, 7 ft. above the former berm elevation, 60 ft. in width, was, to act as a counter-balance, and counteract any further tendency to slide, constructed.

Only one of the slides or sloughs in the Lacour Levee has so far been thus cut away and partially restored, work being interrupted by the early rise in the river. This has, however, fortunately since remained high enough to cover the failure, and has so far shown no tendency to further movement.

Sarpy Levee, in the Parish of St. Charles, Mississippi River, Left Bank.—Here the levee built by the Pontchartrain Levee District again cracked open in four places in 1919, averaging from 75 ft. to 250 ft. in length. The entire river side slope, with part of the crown of the levee, over these sections subsided about 6 ft., and moved out across the berm into the borrow pits. The same sections had been treated for subsidence, sloughing, etc., during the fall of 1918, by restoring them to grade; but, after remaining stable for about six months again subsided in the same manner as at first described.

It was then decided to cut out the subsided sections to a depth 14 ft. below grade, and utilize the material thus removed to construct a false berm, 6 ft. high and 40 ft. in width measured from the toe of the refilled section.

This berm was completed, the cuts refilled, and no movement has been noticeable since the recent completion of the work.

The soil in this vicinity is what is known and generally classed as "buck-shot" earth, and if properly handled should not have given any trouble. However, a narrow berm and rather deep pits crept in, here and there, and a considerable amount of soft material from the bottom of the pits was placed in the side of the base of the levee before the dryer top earth was available. The weight thus superimposed upon the softer material caused the latter to yield and recede, producing slides or sloughs.

With the influence of the counter-balance resulting from the false berm, it is believed that the present section will stand up and thus effect the remedy sought for.

Duplessis, in the Parish of Plaquemines, La., Mississippi River, Left Bank.—Here a new levee was projected in 1919 immediately in the rear of a levee constructed in 1909, and where considerable sinking developed at that time. The character of soil was the usual black clay existing in the caving bends of the Lower Mississippi River and no slough, depression, or unfavorable foundation condition was apparent except possibly the low elevation of the ground surface. In the instance of the 1909 Duplessis Levee, the average ground elevation was about 24.5 Cairo Datum, and the required net fills averaged 9.7 ft. with the customary additional requirements of one-fifth for shrinkage. In the case of the 1919 Duplessis Levee, the location was retired 120 ft., falling on ground having practically the same average elevation as the previous levee, but in order to conform with an increase in grade, the required net fills varied from 9.7 to 10.7 ft., averaging 10.2 ft. In addition to the usual one-fifth for shrinkage, an arbitrary increase of 1 ft. was required to provide for anticipated settlement in excess of shrinkage. Accordingly, the required gross grade of the 1919 levee, was practically 37.8 Cairo Datum as compared with the gross grade of 36.2 which applied to the 1909 levee.

Having in mind previous experiences with subsiding levees, it was decided to omit the muck ditch, to prescribe and increase the width of the berm from the usual 20 ft. to 40 ft., and specify a limiting depth of 4 ft. for the borrow pits—which later specification involved no expense or difficulty to the contractor inasmuch as plenty of material was available in the abandoned levee. The new levee was built with a drag-line machine on one run, and upon the completion of the work, receiving levels showed a gross grade varying from 36.2 to 36.7 Cairo Datum. The previous levee built in 1909 with a wheel-barrow force, with lesser gross fills, but with a muck ditch in the base and a 20-ft. berm was found, upon completion, to be below the required net grade of 34.5 Cairo Datum, and after restoring shortages calculated to bring it to a revised gross grade of 35.5 Cairo Datum, upon final completion was found to be barely up to net grade. The contributory effect of muck ditches and narrow berms, and deep borrow pits, to subsiding or sinking levees is clearly brought out in the above parallel cases.

Palmer Place, in Bossier Parish.—A part of this levee, during construction, subsided at a point where it crossed an old "lake bed," some 300 ft. in width. This lake bed had been dry for several months prior to the commencement of the new levee and no sign of trouble was manifested until the banquette had been constructed to full grade and section, and the levee proper practically brought up to gross grade. The levee then subsided about 3 ft. and moved slightly riverward, while the banquette on the land side remained intact. This banquette was 40 ft. on top and built about level with the natural surface of the ground on each bank of the lake bed. Wheel scrapers were employed in the construction of the levee for which the contractor had attempted to secure some material from the bottom of the lake bed. He was, however, only able to excavate to a depth of about 2½ ft. deep on account of bogging. At the time that the levee first subsided, it was noticed that water was being forced up into the pit not far from the edge of the berm. A section of ½-in. pipe, 20 ft. long, was easily shoved down at this spot for practically its full length, by the efforts of only two men, only the last 3 ft. requiring their full weight. It was, therefore, concluded that the cause of subsidence was due entirely to a soft and yielding foundation. The movement was towards the river side of the embankment, while, undoubtedly due to the presence of a banquette on the land side, none occurred in that direction. Instructions were issued to the contractor to slowly proceed with the work, care being taken to place the bulk of the material only along the axis of the levee, so as to precipitate subsidence immediately thereunder until either all soft material beneath the foundation of the levee had been displaced, or sufficient of it pushed out along the river toe of the levee to act as a counter-balance. The instructions were followed, but subsidence continued for a total of perhaps 8 to 9 ft., but coincident with the subsidence, the berm between the river toe of the levee and the edge of the pit was forced up by pressure until it corresponded very nearly in grade with the banquette along the land side of the levee. This was a typical case of subsidence due principally to soft foundation and responded perfectly to the curative methods prescribed. Little, if any, further subsidence has occurred since the completion of the work five months ago.

Causes and Remedies for Subsidence.—Little or no material advance has so far been made towards everywhere establishing the responsibility for conditions inducing subsidence or sinking in levees, nor the final treatment thereof, beyond what was presented in the previous bi-ennial report. This may be summarized as follows:

1. Physical defects in substrata or foundation, due to local conditions.
2. Narrow berms.
3. Deep borrow pits.
4. Manner of placing and distributing material in embankment.

Number 1 may be determined by borings, tests of resistance to superincumbent weights, etc., the proper safeguards to overcome movement to be formulated and applied in advance of construction.

Numbers 2, 3 and 4 are simply questions of specifications, and their enforcement.

Cutting out the disturbed portion of an embankment, loading the berm and pit therewith, and restoring the section of the embankment with selected material after sinking or subsiding has occurred, has, in most cases, undoubtedly brought about corrective results. But this does not go far enough. It is certain that sinking and subsiding levees will continue to present their dangers and problems, and it follows that the determination of the economical means between the costly methods of dealing with such sinking or subsidence, after they occur, above described, and such as might be formulated therefor in advance, is a subject which should continue to invite the careful consideration and thought of all levee building authorities.

How to Pass Steam Shovel Under Low Wires.—A simple trick that may not have occurred to some operators of small shovels is described as follows in The Excavating Engineer: If you are moving your shovel through city streets and come across a low wire which the boom can't clear, take a piece of plank 10 or 12 ft. long, set it on the point sheave, get under the wires with the outer end of plank and using the sheave as a fulcrum pull down on the inner end, thus lifting the wires. Then move your shovel ahead and let the wires slip along the plank.

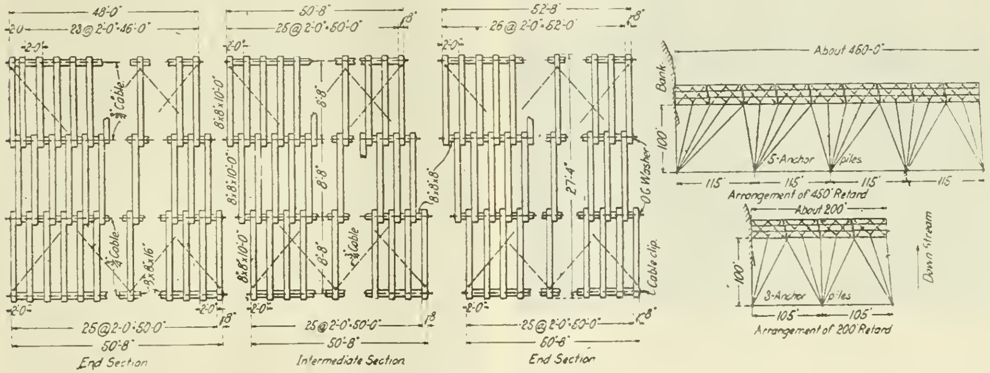
Flexible Rafts for River Bank Protection

In common with many other railroads, especially those in the Mississippi valley, the Chicago, Burlington & Quincy Ry. has had trouble at various places due to encroachments of river currents on its embankments and due also to the liability of shifting currents to completely change the low water channel of the stream, thus making changes of alinement sometimes necessary.

On the east bank of the Missouri River near Folsom, Ia., about 14 miles south of Council Bluffs, the C., B. & Q. Ry. is at present trying out some flexible rafts anchored in position, but free to give with the rise and fall of the water. According to an article in "Railway Age," from which the following is taken, it is expected that these rafts will take the place of or at least render more permanent the far more expensive installations of mattresses, stone dykes, and other forms of revetments.

A former installation of retards consisting of log rafts anchored in position and its upstream edge sunk by unloading rock upon it had given only partial protection.

Since the original installation of retards while partially afloat had been to some degree successful in depositing silt and thus forming bars along the shore, it was decided to expand this idea and build raft retards that would float under all conditions. The retards decided upon were built from 8-in. by 8-in. by 10-ft. pine ties with 1¼-in. holes bored in 8 in. from each end. These ties were threaded on ¾-in. cable of which four strands per section were used, thus giving a raft 27 ft. 4 in. or approximately three tie lengths wide, allowance being made for the distance from the ends for the holes. The ties were spaced 2 ft. center to center by using ties cut 16 in. long bored 1¼ in. the long way and placed between each tie on the two outside cables, with blocks 8 in. long of the same material on the two inner ones, the cable ends being pulled through heavy washers and held by strong clips at the ends of the section. The sections made were approximately 50 ft. 8 in. in length and braced by ¾-in. cables running from the corners to the opposite center on the long sides, and fastened where they crossed the ties by large staples, the ends being threaded through the corner ties and around the main cables where they are held securely in place by large steel clamps. In addition large timbers were made fast to the edges of the rafts to act as floaters in case a large amount of debris should come down on the raft. This was done only on the upstream raft. This method of construction gave a raft not only strong and durable but exceedingly flexible in every direction.



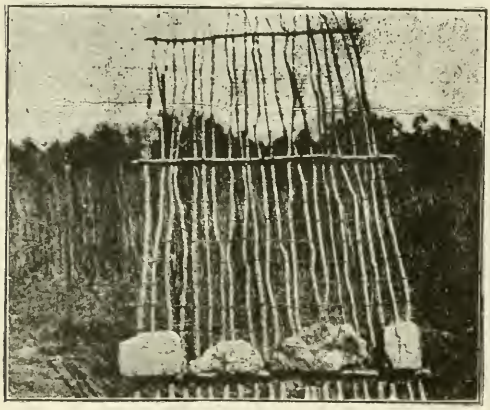
Detailed Plan of Flexible Raft.

The handling of the rafts was simplified by building them on barges which were towed to the desired location where the rafts were made fast by ¾-in cables running from the centers and joints to anchor ples, each pile holding 2 sections and the larger pulled out from under them, old boiler flues threaded on light cables being used as rollers. Reinforced concrete piles were used for anchors, being jetted down until their tops were about 15 ft. below the river bottom.

The piles were spaced opposite the joint between every other section and formed approximately a 45° angle with the shore. A short section was also added to the shore end of each raft which was fastened both to the raft proper and to deadmen ashore by means of cables, the idea being to increase the length of the raft so that with the advent of high water there would always be one end of the raft resting on the bank. As a protection against the possible chance of current washing around the shore end, mattresses made from bundles of willows were sunk along the bank by unloading rip-rap on them.

The completed installation consisted of three separate retards spaced along the bank approximately 1,250 ft. apart. The upstream raft or raft No. 1 which was 450 ft. long and consisted of nine sections, was anchored to five piles, the shore end being about 2,200 ft. from mile post 480. Rafts No. 2 and 3 were each of four sections and about 200 ft. long, raft No. 2 being anchored slightly upstream from where the diverted or split current struck the bank and the cutting action was especially severe, while raft No. 3 was installed near a small point of land that was being rapidly undermined by the swift current of the river, the channel being narrowest at this particular spot.

The actual retarding of the current was not affected so much by the rafts themselves as by the installation of aprons on the downstream edge. These aprons consisted of panels constructed of willows from 12 to 14 ft. long set up and down, well braced and interlaced with wire fencing, each panel being about 7 ft. wide with three cross pieces. The entire apron was weighted down by the addition of large stones held in position on the bottom brace by looping the fence wires around them. The completed aprons were then lowered over the downstream side of the raft and the upper part fastened by wire braces running back some 10 ft. from the edge of the raft and of such a length that the raft could have considerable movement without disturbing the apron. After the stones weighting the aprons have become embedded in the sand and deposited by the current silt and after enough has been deposited to hold the aprons in position the wire braces will be cut, leaving the rafts free to rise with the water. The shallow inshore sections were handled by working willows into the river bottom without the necessity of constructing panels, lacing them together at the top with wire and making them fast to the raft in a manner similar to that for the aprons. As in the case of the floaters, raft No. 1 was the only raft to be constructed with aprons, including the inshore sections, though the ultimate intention is to construct all of them in the same manner.



Typical Retarding Apron.

While the installation to date has proved very successful in the handling of the Missouri River at this point during low water, it has yet to be tried out during high water. However, as it was designed pre-eminently to retard high waters and as its action up to now has been along the lines planned, considerable confidence is felt by the officers in charge that it will do all it was designed to do. The contemplated action during high water is similar to that which is now going on, i. e., the forming of bars both under the raft and on the downstream side, leaving the raft floating free or practically free at all times. Where a large amount of debris, etc., fouls the upstream edge only the upper third of the section in question will be sunk, the depth depending somewhat on the amount accumulated, the tendency being to float the debris over the surface of the raft, due to its flexibility and the action of the current, with no one section being completely sunk for its full width. With the receding of the waters the raft may be left either entirely or partially supported by the bar formed, in which case there will be some cutting along the midstream edge that will continue until the raft is again completely afloat when, with the resuming of the retarding action, it will necesarily cease.

Why College Men Do Not Follow Railroading

In an article contributed to "Railway Age," C. B. Breed, Professor of Railroad Engineering, Massasschusetts Institute of Technology, has brought out points not mentioned by other educators quoted in a previous issue of Engineering and Contracting. We quote from Prof. Breed as follows:

Railroading should offer one of the most fascinating careers to be found. It should teem with interesting problems of the kind which will feed and satisfy the trained mind. The plain fact, however, is that it does not attract the young progressive college man.

Youth is as interested today as ever in the kinds of problems which are met and overcome daily on every well managed railroad. He is merely the grown up boy who would look forward to running a real transportation system with the same zest that he evinced only a few years ago with his toy railroad. The average college man has plenty of enthusiasm and ambition. He needs to be given an opportunity to continue the development of his judgment, his initiative and resourcefulness when he goes out into life.

During the four years of technical school he has been solving one new problem after another in quick succession. His mind has been crowded with new and interesting information at a rapid pace. He has been taught to lay aside the underlying principles of these various subjects in such a manner as to make them available for later use, but he has used them only to a limited extent because neither the school room nor the laboratory can imitate, except in a very limited degree, the real problems which he will meet in the life for which he is preparing. He therefore leaves college with a hunger to tackle life's problems and he expects to work and work hard. He expects these problems to be presented in as rapid succession as he has been accustomed to in the past four years, and if he does not meet them at the start and in numbers and degree such as will tax his mental strength, there is a slowing down of his mental process and a consequent lack of interest. It may be said, and with some force, that he should expect to serve his apprenticeship of drudgery as have many of the present leaders of industry; but to obtain from this product, the college graduate, the results which may properly be expected of him, this product must at the start be understood by his employer. Herein lies one of the faults often laid at the door of the college trained man, namely, that he cannot happily adapt himself to simple drudgery work. The plain fact is that his training has been quite the contrary. He has been running in high gear for four years and to throw his mind into low speed suddenly is too great a strain for most active minds. His work, then, should attract his interest from the start, it should tax his abilities, and if these conditions exist his character will overcome any prejudice he may have against the drudgery part of his service. He cannot be expected to be content if his physical self is employed while his mind remains idle.

Hint on Digging Out Buildings with Steam Shovel.—When a boulder is encountered in earth, it is a temptation to "let 'er have it," and try to rip it out without digging around it first, states The Excavating Engineer. The sudden strains of this kind of digging are tremendous. It is far better to dig the loose material from around the boulder, and then go to it. The use of the boom engines is one of the great secrets of this kind of work. If you cant't get your teeth under a boulder, it is a waste of time to try to push it out, because the push that can be exerted is not in an effective direction. It is always better to take extra time to dig around, until it is possible to get a hold underneath with the teeth. It will be found that no time will be lost in so doing.

Cost of Organizing and Financing a Public Utility Project

In the development of a public utility there are certain preliminary steps which must be taken before the project can be said to have been finally launched. These embrace the development of the project and the securing of sufficient capital funds for preliminary outlays and for the actual construction. All of these steps involve the expenditure of money. The percentage to be provided or set aside for each of these steps is discussed by Mr. F. B. H. Paine in a paper presented at the spring meeting, in May, of the American Society of Mechanical Engineers. The paper was prepared by Mr. Paine in July, 1916, and is in fact a report on a particular property. In order to adapt it to the requirements in the present instance a few changes have been made—those that make it read for a general rather than a particular case. The paper practically in full follows:

Before the construction of the physical property of a utility can be begun, even before the engineering and other plans for that physical property are begun, there are certain preliminary steps necessarily to be taken, which involve much effort, time, and expense, and which are incurred at much risk of entire loss before the project as a whole can be said to be finally launched. These steps embrace the company's rights from the public arrangements for the necessary capital funds with which to reimburse itself for preliminary outlays, and funds with which to construct the physical property necessary to fulfill obligations to the public incurred and incident to its rights to conduct a public utility business.

I will outline these preliminary and necessary steps, state their reasonable costs, and the bases of my estimates. Each indicated percentage, or their sum, should be applied to the total direct and indirect construction cost, including administration and law expenditures, interest, and taxes during construction. I have placed them in three groups:

The Development of the Project	2½ per cent
The Cost of Money	5 per cent
The Promoter's Remuneration	5 per cent

Inasmuch as the preliminary effort, time and expense, the cost of money and the promoter's just remuneration vary proportionately with the breadth, the scope, and particularly the magnitude of the property, they may most conveniently be expressed as percentages of the cost of producing a new property or the estimated cost of reproducing an old property. These three groups are as absolutely essential to the service of the public as the physical groups themselves. Indeed the latter are only made possible by the former.

The Development of the Project.—The items listed below are intended to show in barest outline, by headings the nature of the preliminary problem. It is not intended to list specifically each and every feature detail nor can I possibly estimate in detail what each item has or would reasonably cost because the items are all so interrelated and interdependent that no sharp line can be drawn between them. We can, however, estimate upon the cost of this group as a whole, with reasonable accuracy.

1. Conception of the project.
2. Determination of its scope and territorial breadth.
3. Preliminary outline design and preliminary estimates of cost.
4. Estimates of operating expenditures, of operating revenue and resulting profits.
5. Prospectus or description of the project.
6. Development of the financial plan.
7. Legal and other advice.
8. Negotiations with bankers and underwriters for capital funds.
9. Negotiations with state and community governmental bodies necessary to secure the state charter, franchises, and the approval of the franchises, prospectus and financial plan by the Board of Public Utility Commissioners, and other such matters, but not including any payments to the public for the public rights, nor including any valuation of those public rights.

The old accounting systems were never kept in sufficient detail to show the costs of this group, which I call "Development of the Project." In recent years, however, there have been instances where such costs are approximately known, and there have been many estimates and allowances made by commissions and courts. The percentage allowed on the cost of physical property has, as a rule, fallen within the range of from 2 to 4 per cent, according to the size of the property, and state requirements.

The first question is, therefore, how reasonably to estimate the cost of these preliminary requirements as if they were to be incurred as of the present day with the construction of a great public utility system in view? The necessity for the preliminary work and studies is patent to everybody; the law of the state makes them absolutely essential. That they will cost a great sum of money is obvious; and equally so that the amount involved will be approximately proportional to the magnitude of the project. At this stage of consideration the property being appraised must be looked at as a project; it cannot become a reality until after the preliminary steps have been taken.

The work involved in the development of the project is performed by the same type of men as are concerned subsequently in the administration of the construction of the property and later in its operations. From general experience we know that the effort and time involved would at least quite equal that incident to the physical construction of the projected utility; and it may be fairly assumed that the expenditures involved in the development of the project would be substantially equal to the cost of the administration and legal expenses during construction. Therefore I have so estimated it.

It costs about the same to administer the expenditure of a million dollars properly, for whatever purpose the money be spent. If during a year the expenditures of a utility corporation for operations and for new property amount, say, to ten million dollars, and if in the same year the administration and legal advice costs $250,000, or 2½ per cent of the money expended, that percentage may reasonably be taken to represent the cost of administration and legal advice during the construction of the property; and it may also be taken to represent the cost of the development of the project, for the reasons given in the preceding paragraph. I have found from a study of public utility companies' accounts at least 2½ per cent of the money spent for operating and for construction was the cost for administration and legal expenses, as I am here using these terms.

This method of estimating the costs of development of the project would only fall into error where there are some peculiar or unusual conditions, as in a particular case. In some states there are certain conditions which make for a lesser cost of securing the public rights, gaining approval of them and of the financial and other plans; and in other states the public requirements are such as to increase these costs. In some states, for some kinds of utilities, no local franchises are necessary; in other states there is still no controlling body like public utility commissions. Where there is no occasion to obtain approval of any local franchises, or of any project with its prospects and financial plan, the preliminary costs are correspondingly less. But where separate charters, corporations, and other forms are necessary in each political subdivision of the state, and the necessity exists for securing approval of the controlling body, for each of these subdivisions, the preliminary costs are correspondingly more.

Cost of Money.—In order that money may be secured for a particular enterprise, such as a public utility, there must be a cost incident to its acquisition; not only a cost incident to the acquisition of the first money needed, but for each enlargement of the property. This is always true of every such enterprise and always will be. This cost of money is sometimes, in fact, is usually, merged in and becomes a part of what is generally termed "discount" on such bonds and stocks as are sold.

I am here referring only to that part of discount which is incident to the expense of procuring the money with which to construct. The corporation might sell its securities "over the counter," which would involve an expense, or they might employ agents for the disposition of their securities (employing the word security somewhat broadly to include stocks, notes, etc., as well as first mortgage bonds), commonly known as brokers, underwriters, bankers, etc.

When we wish to rent or sell real estate we employe a real estate agent to do it for us because that is his business and he can do it and make a profit at a less cost, or to better advantage, than we could ourselves. There is a cost in either case attendant upon each such transaction, i. e., the value of our own time and effort taken from our own ordinary occupation versus the payment of money to an agent whose ordinary business it is.

Funds with which to construct a property of any considerable magnitude are invariably and necessarily secured from the world's money markets. No locality, or not one market, would be sufficient for the needs of a large enterprise. Funds from these world money markets are invariably supplied through bankers or underwriters, who for themselves make an investigation of the property from the engineering, legal, and commercial points of view. They must bear this expense as well as the expense of selling to the ultimate buyer. They must also assume the risk of changes in the financial situation, or of error in judgment as to the salability of the securities and the price that they will command at such times as the corporation needs the funds. Not infrequently the banker or underwriter is compelled to carry issued securities of a high-grade character for long periods, while the utility gets its money as needed. The public's demand for service cannot be denied whether the money market is favorable or unfavorable. The practical necessities of the case make it wise for a utility company to secure its funds through agents or underwriters who assume the burden of the risks and the expense of reaching the widest, greatest world's money markets. The cost of money is by no means "velvet" to the banker or others who underwrite an "issue."

Money is needed for the stock yards of Chicago, for the water supply of New York City, for the tramways of Tokio, or the telephones of New England. Wherever it may be there is a cost incident to getting money for undertakings requiring capital. That cost is a proper capital charge, the only question being what is a fair amount to allow.

During the past two years (1914-16) I have been under the necessity, and have had the opportunity and facilities, of informing myself as to the cost of acquiring money in the case of 16 large and well known utility companies, with 19 issues of the highest grade bonds, rated in Moody's Analysis of Public Utilities as "AA" or "A," and marketed within the period from 1908 to 1914. The result of my investigations was to find that the cost incident to the disposition of the senior ("AA" or "A") highest rated securities of these large well known utilities was 5 per cent; the discounts were much more than that. The cost incident to selling bonds rated by Moody was "BA" and "BAA," found in the same manner, was 7.9 per cent.

The property of allowing this item as one of the proper elements entering into the fair value of utility has been favorably passed upon by commissions and courts in this country, but the clearest and most complete analysis is that of the English Justice Lawrence in the Railway and Canal Commission, Royal Courts of Justice, in the condemnation case of the National Telephone Company, Limited, vs. His Majesty's Postmaster General. This covers the questions so completely that I quote from that part of the decision dealing with the cost of money:*

> Next, it is said that the cost of raising the capital necessary to construct the plant is not an item to be taken into account in finding the cost of its construction. This does not mean the cost of raising the price to be paid by the Postmaster-General under this award. It means the cost to which any one must be put who attempts to construct this plant. The method prescribed by the House of Lords for ascertaining value is to consider what it would cost to construct the plan, that is, would, as a fact, cost.
>
> The first question then is, would it, in fact, cost anything to provide the necessary capital? The company have given evidence by way of example, that it costs them 4.41 per cent to raise 5½ million pounds. No one has given evidence that it would not cost anything, nor has that proposition been put forward even in an argument. I know of no commodity and of no service that can be procured as of right for nothing. I am clear, that as a fact, money cannot be procured for nothing. It was further argued that this item of cost was to be attributed or charged to the business and not to the plant. In so far as this argument excludes the cost of raising any capital other than that required in order to construct the plant, I agree with it. We have nothing to do with the cost of raising any capital other than the amount which would be necessary in order to construct. If the argument means that even this part of the capital raised should be attributed to the business and not to the plant, I am unable to follow it. It seems to be founded on some conventions of bookkeeping, proper in their own sphere, but which have no relation to the problem under consideration, viz., what would it cost to construct the plant? The cost of getting the money to pay for the materials, labor, etc., has no nearer connection with the business than the materials and labor themselves.
>
> It has been said that it cannot be an element adding to the value of the plant. The thing transferred here is the plant "in situ," and the cost of construction, less depreciation, is the method by which the value has to be ascertained. It follows that every expense which is necessary in order to construct is an element to be considered, and it has to be considered because it is necessary in the process of construction. The thing to be transferred, say a pole, must be procured, transported, and erected; each of these steps is necessary to the existence of the pole "in situ"; each of these steps cost money, and raising this money is itself an expense and is one as necessary to the existence of the pole as any of the other steps.
>
> This is clear even in the case of one pole, but when the money required amounts to millions, it becomes clearer, for no one has millions of pounds in his pocket, or even I suppose, on current account at his bankers. The result of this is that this cost stands out and is seen clearly. It has not become merged in less conspicuous matters, as it may do in illustrations like motor cars and pianos put to us by the Solicitor-General. The price of these, as of all things in which there is competition, is governed by the market price, but even this, if the market is to be staple and sound, must cover all the items of expense necessary to production. It is not true to say that this involves the proposition that the value of plant varies with the credit of the constructor. The cost to be considered is the cost to the hypothetical constructor who is a person in good credit or, in other words, what it may cost any constructor, even the Postmaster-General, who has the credit of the state on which to raise the necessary capital.
>
> Again, this does not involve the conclusion that the cost of raising capital should be added to the price again if the property should be transferred a second or a third time; it is an item of value once and once only, namely, on the construction of the plant, and it is merely because it is necessary in order to construct that this item comes into the calculation at all. That it must be included is apparent, if it is tested in a case in which the sale takes place immediately upon the completion of the construction.

I call special attention to the following sentence: The cost to be considered is the cost to the hypothetical constructor who is a person in good credit. With this part of the decision I personally do not agree when applied to establishing a fair value for another company differently situated. The Board of Public Utility Commissioners does not deal in condemnation or confiscatory matters, but does deal in matters establishing a fair value, among others. Fair means more than that which just avoids being confiscatory.

It is obvious that the cost of money is greater on that part of the capital raisel on the junior securities than on the senior securities; greater for small undertakings less well situated with respect to the money markets than for large properties very well situated; greater for securities of any class of low rating, than for those of the very highest rating. It does not seem fair to me, therefore, that the allowed cost of the money with which to construct should in all cases be only that allowed in the most favorable circumstances. It follows in my judgment that the fair cost of money necessarily raised for a new enterprise, or for a utility whose securities are not of the highest standing, would be more than 5 per cent—as high as 7.9 per cent. That is the percentage which I found it had cost to sell bonds rated by Moody as "BA" and "BAA."

Securities issued by a corporation under a general mortgage are often classed as "Collateral Trust Bonds." They represent fairly the average, or the mean, of the credit attaching to the various senior and junior issues of such a corporation necessarily issued to raise all the money needed to construct the whole property. The highest grade first mortgage bonds rated in the "A" group by Moody probably could not be sold in amount more than 60 per cent of the total money required. The remaining 40 per cent would have to be acquired through the issue of other forms of junior securities such as common and preferred stocks, second mortgage bonds and collateral trust bonds or notes. It costs less to sell the former than it does the latter for the reason that the first mortgage for a limited amount relative to the size of the property has a higher credit than the junior securities. A first mortgage bond such as I have described absorbs in addition to its own proportion of the corporate credit, all the credit underlying the junior securities as well, and leaves all the risk of the business upon the shoulders of the junior securities in varying degrees according to their degree of juniority, if I may coin a word. Therefore, when the cost of money with which to construct the whole property is taken as that which it would cost to sell only 60 per cent of the most precious, most easily sold part of the securities it in my judgment amounts to confiscation of a part of the cost of money involved in raising the rest of the necessary capital funds. That is why I think that usually the fair amount to allow would be more than 5 per cent and might easily be 7.9 per cent of the cost of the property devoted to the public use.

However, under the most liberal interpretation of the phraseology of Mr. Justice Lawrence's decision in the condemnation case referred to, it is the cost of money with the best of credit which is to be considered; therefore, the measure I adopt as the "cost of money" with securties rated "BA" or "BAA," is the cost of capital funds secured for utilities of the highest credit, best salability, such as first mortgage bonds rated "AA" or "A." I take this as the measure to order that my estimate may be regarded as ultra-conservative, that it many be accepted as the very minimum.

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*Commission Leaflet No. 16, April 1, 1913, p. 507, published by the American Telephone & Telegraph Co.

I arrive at 5 per cent as the cost of money in the following manner. Let us assume that the securities are sold at less than par, or less than their face value. A part of the difference from par is due to the cost of obtaining the money. This part, as I have shown, belongs to the cost of construction and is therefore proper to capitalize. The remaining part is an interest adjustment necessarily made to satisfy the money markets at the moment of sale which is true discount and may not be a proper capital charge.

Whatever the interest adjustment, whether discount or premium, it is easily determinable as it is the amount less or more than par, or face value, at which the securties are taken by the general public or ultimate purchaser. The cost of money is the difference between the price paid by the ultimate purchaser and the net amount received into the "till" of the corporation. If securities are sold to the ultimate purchaser at above par it simply means that the par, or face interest, is higher than necessary to satisfy the money market. The same security is sold sometimes above par and sometimes below par, according to the demand of the money market at the moment of sale. Money is a commodity which varies in its market requirements much as wheat or other commodities vary. The cost of money, however, is distinct from discount or premium and is the difference between that paid by the ultimate purchaser and the amount received into the corporation till.

As it is the cost of raising all the money which it would take to construct at the present time, the per cent of the cost of money is to be applied to the entire estimated cost of construction. Generally speaking, the money with which to construct is secured through the sale of various kinds of securities—common stock, preferred stocks, second mortgage bonds, notes, as well as first mortgage bonds. Let us assume three examples:

Example 1—	
Par value of bond	$1,000
Interest, per cent	5
Bond sold to ultimate purchaser for	975
Net amount received into corporation till	925
In such a case the cost of the money would be the difference between $925 and $975, viz., 5 per cent, which is properly capitalized	50
The interest adjustment required by the money market would be a discount of 2½ per cent	25
Example 2—	
Par value of bond	$1,000
Interest, per cent	5
Bond sold to ultimate purchaser for	1,030
Net amount received into corporation till	980
In this case the cost of the money would be as in the first example, 5 per cent, properly capitalized	50
The interest adjustment required by the money market would be a premium of 5 per cent	30
Example 3—	
Par value of bond	$1,000
Interest, per cent	4
Bond sold to ultimate purchaser for	800
Net amount received into the corporation till	750
Here again the cost of money properly to be capitalized would be 5 per cent	50
The interest adjustment required by the money market would be a discount of 20 per cent to adjust the assumed market requirement of 5 per cent interest	200

In arriving at my conclusions as to the cost of money I first took the per cent cost incurred in the sale of each of the 19 issues rated at "AA" or "A" of the 16 corporations and found that by adding together the per cent costs and dividing the sum by the number of issues the true average per cent cost was 5.1 per cent. I then multiplied the par value of each issue sold by the per cent cost incurred in that particular sale which gave me the cost in dollars for each case; and by adding all these together I found it had cost $3,164,000 to market $64,845,000 par value of bonds, or 4.9 per cent; 5.1 per cent being the average of the percentages; 4.9 per cent being the weighed average, I took the mean, or 5 per cent as representing the cost of obtaining money. I found in a similar way that the cost of marketing the "B" group of bonds was 7.9 per cent.

Promoter's Remuneration.—"I know of no commodity and of no service that can be secured, as of right, for nothing."—Mr. Justice Lawrence. What is it which would induce any promoter or any group of persons to make such a preliminary expenditure as I have described under "development of the project" and then provide the money and assume the two great risks; first, that the project would fall by the wayside and never come to fruition at all; second, its failure afterward? Why should the promoter render such a service as has been rendered to the public in providing most existing utilities. The answer is: remuneration for service rendered. Promoter's remuneration, as dealt with here, is the cost to the public for the promoter's services. It is entirely distinct from the cost of the preliminary development of the project, and the cost of securing the money with which to build the property.

There must be some inducement to bring about the activities of the promoter in the particular enterprise, and that inducement is profit or gain; and for it he renders a valuable service. The service of the promoter is essential at all stages of the utilities' development; not only in the beginning, but with the addition of each increment of capital needed for enlargement or extensions. Enterprise without the service of a promoter is inconceivable. The Railroad Securities Commission appointed by President Taft, of which Arthur T. Hadley, president of Yale University, was chairman, said on page 30 of their report:

> We are told that the profit of the promoter represents a wholly unnecessary burden upon the American public, and that so far as this profit can be done away with it will be good for all parties. Neither of these statements is quite true. The promoters, using the term in a broad sense, may be divided into two classes: constructors who build a railroad whose future is uncertain, in the expectation of selling the stock for more than it cost them; and financiers who induce the public to buy the bonds of such roads. Both of these classes, if they do their work honestly, render useful service to the public. The constructor gives our undeveloped districts the benefit of new roads, which they would not get without his intervention; and if he does his business well he builds the road more economically than anybody else could. The financier renders an equally important service in collecting the capital of the investors to build new railroads or improve old ones.

There are many similar statements made by commissions, courts, and other authorities. I think all commissions have recognized that the services of a promoter should be properly remunerated. The California Commission, in the case of the Central California Gas Company, California Commission reports, Vol. 2, page 120, says:

> The Commission is of the opinion that promotion and organization expenses, honestly and wisely incurred, are as necessary to the success of a public utility and are as properly subjects of a capitalization, as the cost of the component parts of the utility's physical plant or system.
>
> A public authority, in estimating the value of such services, should be liberal, so that men of ability may be attracted to the development of new utility enterprises where needed for the development of the state. The need for a liberal policy in this regard is paticularly apparent in states like California, in which there is still a wide field for legitimate new public utility development.

In City of Danville et al. vs. Southern Railway Co. (1 I. C. C. R. 409, 438), the Interstate Commerce Commsision said:

> This enterprise is a perfectly legitimate one. The men who have conceived and executed it are entitled to a fair return upon the money which has been actually invested in it. They are entitled, in addition, to a reasonable profit upon the ability to conceive and execute a project of this sort.

When a public service commission is determining the fair value of a property, it should make no difference whether the property is old and had been rendering a valuable service, or whether it is new and much desired by the public; the same elements should enter into the value on which earnings are allowed; and whatever is a proper allowance necessary to induce a new and valuable enterprise must also be a proper allowance to give the promoters of an enterprise already in existence, and of undoubted public use, and in which the risk has been incurred and the service rendered.

The service of a promoter having been essential to a particular utility, the property having been built and having rendered a valuable service to the community, it is entirely proper that a reasonable recompense should be made on account of the service of promotion. The fact that the promoter might be the present owner does not in any way affect the equity. If now, when the state for the first time fixes the value and exercises control over the property, it denies remuneration to the promoter an injustice will be done. The promoter might better have gone elsewhere.

Five per cent as a total allowed profit for supplying and building an important property could not be considered an excessive recompense for the effort and risk; and as I have no desire to suggest anything more than a moderate remuneration (I follow chairman Stevens' allowance of 5 per cent) I suggest 5 per cent as a capital allowance to be made on this account in the appraisal of public utility properties.

In the application of the Rochester Corning & Elmira Traction Co. for consent to the execution of a mortgage, and authorizing the issuance of capital stock, the Public Service Commission of the State of New York, Second District, opinion by Chairman Stevens, in Vol. 1 of the report of April 1, 1909, page 166, deals with the whole subject very fully (as it has been by many other commissions), and allowed 5 per cent as promoter's remuneration. That commission has allowed 5 per cent in the case of other projected utilities.

In the decision by Chairman Stevens, in the case referred to, he speaks of the difficulty of determining the exact amount which the promoter should be paid under the varying conditions. He fixed 5 per cent for a proposed railroad, the desirability of which he had passed upon favorably. My judgment is that Chairman Stevens' allowance was too small for such a new project (the road was not built) yet he is a man intentionally fair, of good judgment, and has had good opportunities for observation. Five per cent has been accepted in other cases and is a frequent minimum provision in promoting large enterprises. Therefore, it follows, and my judgment is, that 5 per cent of the cost of a property is the minimum proper capital allowance which should be made.

The M. I. T. Co-Operative Engineering Education Plan a Proved Success

For the past year an interesting experiment in co-operative engineering education has been conducted by the Massachusetts Institute of Technology and the General Electric Co. While the co-operative scheme in itself is not new, several departures from the usual plan were introduced, which have produced decided results.

The class was limited to 30 students, who were chosen entirely upon the records which they had made in the equivalent of the first two years' work of the electrical engineering course at Technology. Included in this group were graduates from Yale, Harvard, Dartmouth, Princeton, the Naval Academy, besides men who had completed their first and second years solely at Technology. The year (12 months) is divided into four 3-month periods, the students spending alternately 13 weeks at the Lynn works of the General Electric Co. and 11 weeks at the Institute, followed by a two weeks' vacation. The group at Lynn is housed together in a fine old residence which has been converted into a modern club house. No break is made in the major studies when the students are at Lynn—courses being conducted at the works in principles of electrical engineering and in general studies. The progress of the students through the plant is regulated, not by the production needs of the various department, but by the advantage which the experience in each department is to the students.

The result of this year's work has been gratifying to the originators of the plan. Because the students were a selected group, were all taking the same course, and were thrown together intimately at work and at the club house, an intense spirit of loyalty to one another, to the Institute and to the General Electric Co. soon became manifest and every man strove to make a reputation for the course. With the students attacking the work in this frame of mind, it is not surprising that their enthusiasm was soon shared by the officials and superintendents of the co-operating company, who are unanimous in stating that the work done in the shops has been pre-eminently satisfactory. As evidence of its approval of the work, the company has increased the number of men who can be enrolled in this year's class to 60 and has already secured a new club house in order to furnish rooming accommodations for them. The new class which has already nearly completed its quota of members will enter upon the work July 6.

Meeting of Texas Waterworks Association.—The annual meeting of the Texas Waterworks Association will be held July 19 and 20 at Austin, Tex.. V. M. Ehlers of the Sanitary Engineering Bureau of the State Board of Health, Austin, is Secretary.

Data on Embankment Shrinkage

A series of experiments to determine the actual shrinkage of the material used in embankments on the lines of the Chicago, Burlington & Quincy R. R. have been made by the valuation department of that railroad. The experiments, followed what is known as the density method, and were conducted under the superivision of H. S. Marshall, valuation engineer, and C. E. Oliphant, cost engineer. The investigations and the results are described in a recent issue of the Railway Age, from which the matter following is abstracted.

The following definitions were used to designate the significance of the word "shrinkage" as employed in the experiments:

Net shrinkage is taken as the lessening in volume of earth as between its formation in the natural bed and its re-formation in the embankment. It is a characteristic presumably due to the breaking up for movement and the solidification in new position under the influence of its own weight and the effects of superimposed loading and impact.

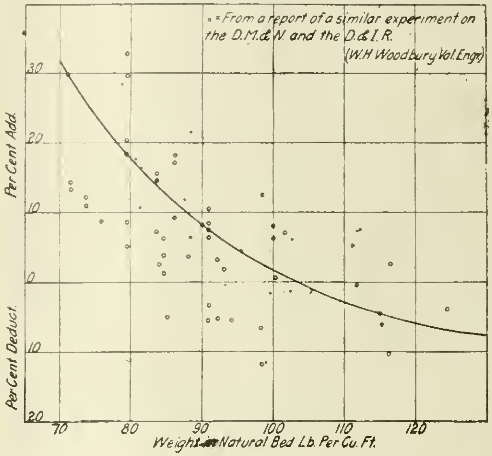

Fig. 1—Curve of Shrinkage, Volume in Embankment to Volume in Excavation.

Gross shrinkage involves, in addition to the shrinkage, the loss during construction and prior to acceptance for operation by wastage on runways and the erosion by the natural elements; also the slight unmeasured general subsidence which obviously occurs under all embankments built upon glacial drift or arable soil.

The density method of determining shrinkage consists of a comparison of the weights of the net metallic contents of equal sized, unmolested samples of a given kind of earth taken from the embankment and from the natural bed adjacant to the excavation from which the embankment was made. The net metallic content is taken to be the weight of the sample after drying—the moisture content being eliminated by heat. The difference in weight is taken as the measurement of the change in volume.

The samples of earth for the studies were taken at points where it could be said or where it was reasonable to suppose that a particular embankment was made from a certain excavation. Geographically, the sampling covered the territory of northern Illinois, northern Missouri and southern Iowa. With possibly some exceptions of points along or close to rivers, the samples are representive of soil said by geologists to have been formed by glacial drift, hence any conclusion concerning shrinkage developed by this investigation may be applicable only to glacial drift formation.

It became apparent early in the course of the experiments that the shrinkage of earth bore some relation to the weight of the earth in its natural bed. Upon this conclusion the shrinkages of the samples were platted in relation to the weight of the metallic content in the natural bed, as shown in Fig. 1. The curve of shrinkage as drawn is merely representative of the center line of the area of the scattered points. It is apparent from the spread of the points that dissimilar materials may have been compared in some cases.

The curve, however, as drawn, surely eliminates extreme errors. A similar curve for the complementary or additive factor was developed in the same manner as for shrinkage and is displayed in Fig. 2.

It also became apparent in the course of the experiments that the weight of metallic content in the natural bed bore a relation to the depth below the natural surface. The metallic content weights were platted in relation to the depth below the natural surface and an approximate curve of the relation was drawn as shown in Fig. 3.

It will be seen from Fig. 1 that the studies so far made indicate that earth, the metal content of which in its natural bed weighs less than 103 lb. per cubic foot shrinks when placed in embankment subjected to traffic but when the metal content in the natural bed weighs more than 103 lb. per cubic feet the material retains a more or less permanent swell.

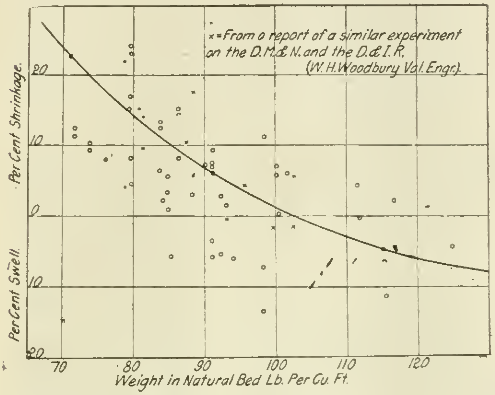

Fig 2—Curve for Additive Factor, Volume in Excavation to Volume in Embankment.

As shrinkage bears a relation to weight and weight bears a relation to the depth below the surface in the natural bed, shrinkage of embankments can be shown to bear a relation to the depth of the material source in excavation below the natural surface. The same holds true for the complementary or addititive factor and a curve of this relation has been developed for this characteristic as shown in Fig. 4.

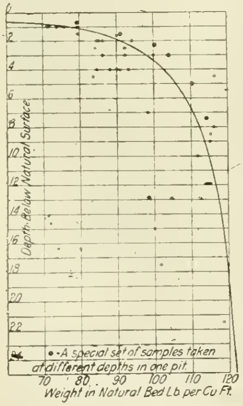

Fig. 3—Relation of Dry Weight to Depth Below Surface.

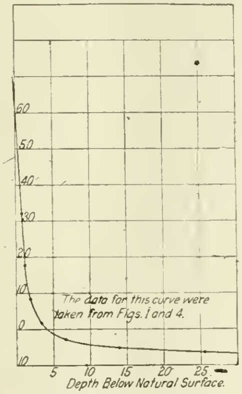

Fig. 4—Relation of Additive Factor Depth of Material in Natural Bed.

If a conclusion can be sustained upon the evidence, it can be said that, for the territory considered, earth in embankments taken from the top 4 ft. of the excavation shrinks; and that from lower depths in the excavation swells. Such a conclusion might seem to mean that the average additive factor applicable to embankments may not be impressive, but upon considering that ordinarily from 60 per cent to 100 per cent of railroad embankments are constructed from excavation in the top 4 ft. of earth the average additive figure becomes appreciable. Practically all side borrow falls in this class and the top 4 ft. of roadbed cuttings contains a relatively large yardage on account of the trapeziodal shape of the roadbed section.

The experiment as drawn has no direct reference to the ascertainment of the miscellaneous factors of gross shrinkage The establishment, however, of the extreme high shrinkage characteristic of surface soil, which is supported by common knowledge of the high porosity and void content of surface soil, indicates an unmeasured subsidence under all embankments. It appears obvious that if surface earth shrinks 40 per cent when used in embankments it will be compressed in natural bed under the superimposed embankment and the effects of traffic. It is easily conceivable that this subsidence may amount to at least 0.2 ft.

Safety Measures in Operation of Gyratory Crushers

Easily applicable safety measures for gyratory crusher operation are outlined in the March-April Accident Prevention Bulletin of the Portland Cement Association, from which the notes following are taken:

When working near a crusher men should wear safety belts attached to ropes, and it goes without saying that it is the company's duty to furnish this equipment and see that it is used. Often men do not use the safety appliances furnished them because the danger involved has not been put before them in the right light. Possibly they do not see the danger, because they have done the same work for years without mishap. Again their superiors may not have made any attempt to enforce the rules which they have once issued.

A recent report received by the Bureau of Accident Prevention and Insurance told of a man who, while working at a gyratory crusher as hookman, was taken severely ill with vertigo. Fortunately the report records merely a case of sickness, but how little would have been required to make this one of the many unexplainable fatal accidents. It is commonly known that a person threatened by an attack of vertigo feels as if surrounding objects were whirled around or as if he himself has been whirled around. There is a strong tendency to fall. If the man in the case referred to had lost his balance and had fallen into the crusher a fatal accident would have resulted. Did the man wear a safety belt? Very likely not, at least the report does not mention it.

Another recent report tells of a man who, while punching rock into a crusher with a bar had the bar caught in the crusher and was hit on the head by it as it swung around. The only result in this case was that his right ear was bruised. Had the blow been severe enough to stun him a fatal accident might have been the result. Did this man wear a safety belt? The report does not say.

In neither of these accidents was any time lost, but if these two companies had followed the method of some of not reporting "trivial things," nothing would have been known of the danger to which two men were exposed. The object of reporting is as much to expose unsuspected dangers as to compile statistics on time lost. When we know the dangers we can guard against them by taking necessary precautions before accidents occur.

Some very severe accidents have occurred at crushers. The superintendent at one plant has no trouble in getting the men to use the belts. It is an absolute rule at this plant that if the crusher men wish to keep their jobs belts must be used. Do not satisfy yourself with the idea that your "conditions are so different," A gyratory crusher, no matter where it is, must be given attention when it refuses to take hold of rock fed into it and the only way this attention should be given is the safe way—with the use of a safety belt and railing. Your men should know this, and it is up to you to bring it to their attention. Do it now before another case of vertigo or tripping on a stone or being hit by a bar sends a man into the jaws of almost certain death.

How to Prolong Working Life of Wire Rope

Suggestions on the use and care of wire rope are given in the May issue of Lubrication, a publication of The Texas Co. The matter following is taken from the above mentioned paper.

Wire ropes are expensive and complex pieces of machinery, yet, people who are buying them find it very hard to get the average employe to take the question of their upkeep seriously. It is easy enough to prove to a man that a rope is expensive by telling him the price, but making him realize that the rope is an intricate mechanism is an entirely different matter. Just why this is we are not prepared to state. It is probable, though, that to many men rope is rope and in their minds the wire rope is nothing more than a strong brother of the cotton clothes line in the backyard—something to be used with no attention to upkeep until it wears out with age and then to be thrown away.

Wire ropes never deteriorate with age. If a properly manufactured wire rope were to be stored away in some place out of reach of water and heat, it would be as fit for use at the end of 10 or 20 years as the day it was made. When wire ropes wear out it is the result of one of three causes:

(a) Mechanical abuse.
(b) Neglect.
(c) Long and efficient service.

A Wire Rope for Every Requirement. It is hardly fair to the manufacturer of wire ropes to use one of his products for work for which it is not suited, but it is infinitely more unfair to the man paying the bills. So many varieties of ropes are made now that we might say that there is at least one for every requirement. Consequently, the buyer who pays a lot of money for a haulage rope and runs it over small sheaves has only himself to blame when the rope rapidly wears out. Yet, this happens every day. When buying a wire rope for a particular purpose the purchaser should supply the rope manufacturer with detailed information regarding the operating conditions, and when the proper rope is received it should not be used on another job under entirely different conditions.

Uncoiling Wire Rope and Overloading.—Wire ropes are occasionally irreparably damaged during removal from the reel. Wire ropes should never be pulled out of a coil in the manner of hemp ropes, as such practice is bound to cause kinks and twists in the ropes which are hard to straighten out and which weaken them considerably. The correct way to take a rope off a reel is to mount the latter upon an axle so that it may revolve. If the rope can be transferred directly to the drum so much the better.

Wire ropes are very frequently overloaded or subjected to sudden stresses. For long service a rope should not be required to carry more than one-fifth to one-tenth of its ultimate strength, the factor of safety depending upon the conditions of operation. Not only do excessive loads strain the rope but even under the most favorable operating conditions the wires of the rope gradually become worn away and their strength reduced. Sudden jerking and snapping is even more injurious to wire ropes than overloading as the sudden strain may actually cause some of the wires to break. The continuous vibration of long ropes is also very injurious, and especially to ropes which have been allowed to become rusty.

Effect of Drums and Sheaves on Wear of Rope.—Poorly designed drums and sheaves are in some cases the entire cause of ropes wearing rapidly. Some wire ropes are made very flexible so that they may be successfully used upon small drums and sheaves, but it should always be remembered that the greater the diameter of drums, sheaves and pulleys, the less the bending action and wear on the rope. The sheave wheels on coal mine shaft hoists are usually about 12 ft. in diameter. Grooved drums are much easier on ropes than the flat variety, but unless the grooves are smooth and of slightly greater radius than the rope they will cut and cramp it causing the exterior wires to wear rapidly. If grooves do not allow a clearance between successive windings rapid wear will also ensue.

Some Forms of Wire Rope Abuse.—Overwinding, that is, the winding of more than one layer of rope upon the drum is a common form of wire rope abuse. This has the tendency to both cramp and wear the rope and rapidly destroys it. Overwinding is especially injurious when the rope is allowed to climb and become crossed in irregular fashion as this causes severe wear and dangerous jerking. Poor alignment of sheaves and drums causes the rope to scrape against the sheave with the result that both are worn. Wood, leather, or hard rubber properly arranged upon the surface of drums materially reduces the wear of the rope.

If there is one operation that will wear out a wire rope quicker than another it is reverse bending over small sheaves. This subjects the wires in the rope to much the same bending as is employed when we desire to break a piece of wire in our hands, and, moreover, a great deal of frictional wear is caused. The sharper the bend the greater the distance which the component wires must move upon one another. A little care in design will usually make reverse bending unnecessary, but should an idler, or some other device causing this condition be in use, every effort should be made to remove it, and the saving which will thus result through longer rope service will justify the expenditure of considerable money for this purpose.

In steel making, smelting ores, etc., some wire ropes are frequently exposed to intense heat. Although in all cases this can hardly be classed as a misuse, the condition, nevertheless, is the cause of the rapid deterioration of wire rope and should be avoided wherever possible. The heat has the effect of killing the core in the rope and also of drawing out the lubricant so that the rope becomes stiff and wears rapidly. Where intense heat is encountered only ropes having wire cores should be used. Ropes having asbestos cores have been made for use in the presence of intense heat, but have not proved successful because of the rapidity with which the asbestos disintegrates.

In the above paragraphs we have pointed out how a rope may be worn externally, but it should not be forgotten that the interior wires will also wear rapidly unless properly cared for. It may not be common knowledge, but it is a fact, nevertheless, that as the rope passes over the sheaves, etc., a great deal of sliding of each wire upon its neighbors takes place. There is also some slipping of the strands upon one another. When the rope is loaded the wires press upon one another with considerable force so there is bound to be a great deal of frictional wear in the interior unless precautions are taken to prevent it. The proper precaution is efficient lubrication, but more than one rope has gone to the scrap heap for want of it. Perhaps some of our friends would have more respect for the humble wire if they only knew that 100 ft. of 1-in. wire rope has 334 sq. ft. of bearing surface. A 35,000 HP. twin tandem reversing engine has been found to have only 319 sq. ft. of surface requiring lubrication.

Neglect Principal Cause of Injury to Wire Rope.—Serious as are the abuses just described, their effect upon the working life of a wire rope are not to be compared to the injuries resulting from neglect. Deterioration caused by abuse is chiefly of a mechanical nature, but that caused by neglect may be said to be chemical and because of its insidious nature much more serious.

The whole story of the chemical destruction of wire ropes may be summed up in one word—corrosion. Corrosion may be caused by damp air, acid fumes and water charged with chemicals. Damp air and chemically impregnated water are nearly always present in mines, and the "copper" water encountered in copper mines is so injurious to iron alloys that the pumps used to remove it are commonly made of pure bronze. Ropes which are alternately wet and dry corrode very rapidly, but it is interesting to note in this connection that ropes which are continuously wet are subject to comparatively little corrosion even when the water contains a small percentage of chemicals. Wire ropes exposed to sea air corrode rapidly unless protected and for this reason ropes used on ocean-going ships are usually fabricated from galvanized wire.

Corrosion has a number of bad effects upon the rope if not properly combated. The first result is that the lubricant applied to the rope during fabrication is destroyed leaving the steel dry and exposed to the acids. A rope that has become dry cannot remain pliable and the power required to operate it is greatly increased. There is little opportunity for dry wires to readjust themselves in passing over curved surfaces and the uneven stress distribution damages the strand and even causes the wires to break. It has been shown that a transmission rope which has been allowed to become dry will become so hot in a short time that it cannot be touched and, moreover, will make a very audible crackling sound in passing over the pulleys. This heat indicates pronounced frictional wear and a condition of rapid deterioration. A well lubricated rope under the same conditions will scarcely become warm.

With the protective film once removed from the wire, corrosion proceeds at a rapid rate and the finer the quality of the steel in the rope the faster will the destruction be propagated. The corrosion pits the wires and reduces their cross-sectional area. The rope is then more rapidly broken up in passing over the drums, not only because of decreased resistance but also because the rope acts more like a solid bar than a flexible cord.

Corrosive gases and liquids are very injurious to the hemp core of the rope, rendering it dry and inelastic and absolutely incapable of performing its function in the rope. When the hemp core falls to pieces the rope is bound to collapse to a certain extent, seriously impairing its strength. Moreover, the lack of the cushioning effect provided by the core exposes the rope to the full violence of sudden shocks. When a suitable lubricant is used upon the rope the hemp core will become impregnated with it and thus serve as a reservoir from which a little lubricant is exuded with every movement of the rope. Care in the form of proper lubrication not only saves the core but also enables the core to protect the wires from corrosion long after the lubricant originally applied to them has been destroyed.

Necessity of Proper Lubrication of Wire Rope.—A wire rope will slowly wear out with use just as any other machine wears out, but it is imperative, in order to get the full measure of service from a wire rope, that it be thoroughly lubricated both inside and out with a highly specialized preparation capable of reducing mechanical wear to a minimum and of absolutely resisting the inroads of corrosive substances. Many products are on the market which will reduce friction. There are some which will prevent corrosion, but those which will do both are scarce indeed. The peculiar operating conditions to which wire ropes are subjected, admittedly make their lubrication a very difficult matter. Ordinary black oil and so-called waste oils are used on ropes, but they possess little value for this purpose as they are rapidly thrown off, do not penetrate to, or preserve the core, and are worthless in resisting the attacks of moisture.

Corrosion in unsuitably lubricated wire ropes is especially serious because of the fact that it goes on unrestricted in the interior of the rope when the exterior appearance leads one to believe that it is thoroughly lubricated. If a rope is obviously in a bad condition it is bound to be regarded with suspicion, but a rope may be falling to pieces inside and yet present a beautiful external appearance. The efficient wire rope lubricant is one that penetrates to the very core of the rope. If the innermost wire is coated the rest of the rope need cause no concern.

It is assumed by many engineers charged with the care of wire ropes, that the initial application of lubricant, made by the manufacturer, should be sufficient to protect the rope for all time. Examination of numerous wire ropes has shown that even under the most favorable operating conditions the initial application of lubricant lasts only a short time, and without its protection the wires begin to wear and the core soon dries up. Periodical applications of a suitable lubricant are absolutely necessary to the efficient operation and longevity of wire ropes.

Track Reconstruction, Per Man, Per Day

In the "question box" of Aera, the journal of the American Electric Railway Association, the following question has been put up and several answers have been received:

"What should be the average number of feet of track reconstructed per day, per man, on tangent track reconstruction, assuming 65 lb. reconstruction in kind on dirt street, not under traffic? Please give conditions governing."

From Los Angeles comes an estimate of 2 ft. per man per day; from Buffalo, 3 ft.; from Montreal, 3 ft.; from Boston, 2½ ft.; from Lincoln, Neb., 15 ft.; from Halifax, ½ ft.; from Covington, Ky., 2 ft.; from Portland, Ore., the estimate for renewing ties and surfacing is 17½ ct. per ft., which at prices obtaining would allow 24 ft. per man per day, but this is admittedly under very favorable conditions.

Development of Liquid Oxygen Explosives

Interesting information on the development of liquid oxygen explosives is given in Technical Paper No. 243 issued recently by the U. S. Bureau of Mines. The paper, which was written by Mr. Geo. S. Rice, chief mining engineer of the Bureau, describes the results of experiments conducted by the bureau at its explosives testing station near Pittsburgh, Pa., and gives an account of the methods of use as developed in Germany, observation on its use by the Germans for destroying French iron and steel plants, and an abstract of a German military paper on instructions for using liquid air explosive.

During the war the growing scarcity of glycerin and ammonia greatly increased the cost of dynamite. This caused the Bureau of Mines to investigate the possibilities of liquod oxygen explosives, which do not require nitrates. Results of the preliminary testing begun in April, 1917, were decidedly favorable. Mr. Rice, while in Europe in 1919, as a member of a committee to observe progress in post-war industries, paid special attention to liquid-oxygen explosive. The Germans were found to have used the explosive, known as "oxyliquit," extensively in none-gaseous coal mines, in excavating subways and tunnels, in quarrying, and in iron mines, as well as for destroying French steel plants.

The explosive was first tested at a coal mine in Germany, in 1897, following Linde's invention of his liquefying apparatus in 1895. Trials made in driving the Simplon Tunnel are said to have been favorable. In 1900, Claude, of France, patented the rectification principle. Linde, in 1902, designed his rectification apparatus. Both types of apparatus are extensively employed in liquefying gases. In 1904, Dewar, of Great Britain, invented the Dewar flask—a container for liquefied gases. Further development of liquid oxygen for blasting purposes was small until the war began. As already stated, its use was widely extended in Germany during the war.

The allied countries, being able to import nitrates from Chile, did not take up its use, but if the war had continued the United States would probably have been compelled to do so. The method will now have to depend on its merits and on commercial conditions.

The experiments of the Bureau of Mines, according to the paper, have shown that a liquid oxygen explosive can be prepared which has a blasting strength greater than "40 per cent" straight nitroglycerin dynamite. This was shown by tests in the standard testing apparatus of the Bureau, as well as in blasting. The procedure adopted was to place a No. 6 detonator in the inner cartridge, a cheese-cloth sack containing carbonaceous material. The cartridge is soaked in liquid oxygen 10 to 15 minutes in an improved container devised by the bureau. The cartridge, frozen stiff, is slipped into a pasteboard container, placed in the hole, a wad of cotton placed on it, a brass tube inserted, and clay tamped round the tube. The hole left by the tube provides an outlet for evaporating oxygen, until the shot is fired.

The advantages, as compared with dynamite and black blasting powder, states the paper, are lower cost per ton of material blasted, elimination of dangers in transportation, from premature ignition, misfires, or unexploded sticks in ore or coal, in handling and thawing, or in storage magazines. The disadvantages are: the liquid oxygen, because of its rapid evaporation must be used quickly after charging, thus limiting the number of shots. A liquefying plant must be maintained near the mine. The explosive can not be used in gaseous coal mines.

Its introduction into mines is difficult, because miners are not accustomed to it. The method offers great possibilities for lessening blasting costs in nongaseous coal mines, and in metal and mineral mines using a chamber method where only a few shots are fired at one time. The chief cost is that of the oxygen, but according to the paper there is hope of a decided reduction in cost through promised improvement in liquefying machines.

Semi-Centennial of Iowa State College.—An engineering symposium was held June 8 in connection with the semi-centennial celebration of Iowa State College. Addresses were presented by Arthur P. Davis, director, U. S. Reclamation Service; T. H. MacDonald, chief, U. S. Bureau of Public Roads, and J. W. Hook, president of the Allied Machinery Corporation

Basement Excavation After Building Erection Was Well Advanced

Digging the basement for a building after five stories had already been constructed was the unusual work done by a Smith excavator and leader for the Walter W. Oeflein Co. in connection with the erection of factories for the Wisconsin Food Products Co. at Milwaukee.

This building was started last November in the midst of a prolonged cold snap which left the ground in a solid frozen state, making extensive excavating practically impossible. Instead of delaying the construction until the ground became soft enough to dig the contractors decided to excavate only space enough for the footings and columns and leave the bulk of the excavating until a later date. The entire space to be excavated measured approximately 300 ft. by 160 ft., with a depth of about 7 ft.

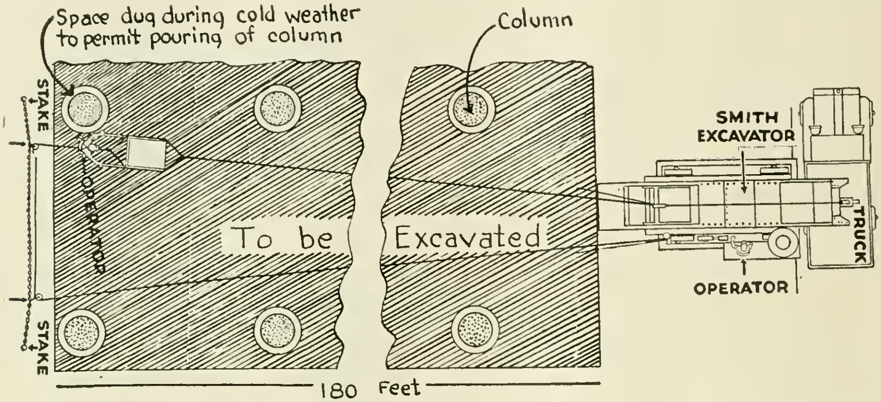

Fig. 1—Sketch Showing Arrangement for Excavating Basement.

The location of each column was marked out and a fire built on the spot to soften the ground. A hole was dug just big enough to permit pouring of the columns and the rest of the structure was continued in the usual manner.

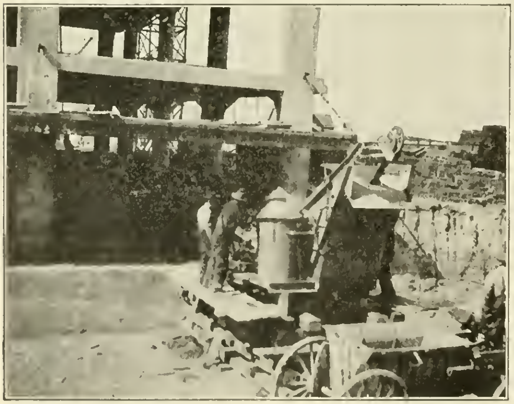

Fig. 2—Discharge End of Excavator.

Fig. 3—Loading Digging Slip.

The fact that the space between the top of the ground and the bottom of the floor of the first story was less than 5 ft. in some places presented an unusual excavating problem. A steam shovel was impossible because of the low clearance and hand shoveling would have been costly.

The excavator and loader was set at the edge of the building in such a position as to give a straight run between two rows of columns. At a point, 180 ft. away from the machine, two stakes, 20 ft. apart, were driven. A heavy chain was stretched between these stakes. Upon this chain two sheaves were hooked, either of which could be unhooked and relocated anywhere on the chain to change the path of the excavation. As shown in the sketch, a heavy cable passed from the hoist drum on the machine, then to the digging slip, then through both sheaves, and back to the retrieving hoist drum on the machine.

As the dirt between one row of columns was removed the excavator was moved to the centerline of the next row. Only two men were necessary for the complete operation—one man at the digging slip and the other operating the machine. Only a limited number of trucks were available which caused the machine to lose considerable time between loads, but in spite of this condition the dirt was moved at the rate of 30 cu. yd. per hour or about 300 yd. in a 10-hour day.

On the side upon which the machine was located was a depression in the ground running the full length of the side of the building and extending about 6 ft. below the basement level of the building. This complicated the digging problem somewhat, but it was overcome by removing the wheels of the excavator and building a crib platform upon which the machine was elevated and mounted.

Syracuse to Have Professorship in Transportation.—The sum of $60,000 has been presented to Syracuse University for the establishment of a chair of transportation. Courses will be given in railroad transportation, water transportation and traffic management.

Effect of Storage of Cement on Its Concrete and Mortar Making Properties

Tests to determine the effect of different conditions and periods of storage on the concrete and mortar making properties of Portland cement have been under way for the past 3½ years at the Structural Materials Research Laboratory of Lewis Institute. The results so far obtained are set forth in a progress report, prepared by Duff A. Abrams, professor in charge of the Laboratory, and published this month by the Laboratory as Bulletin 6—"Effects of Storage of Cement."

Tests were made on three different lots of Portland cement, which had been in storage for periods up to two years. The cements were stored in (A) In Testing Laboratory, a large, steam-heated room on the ground floor of Lewis Institute, temperature quite uniform during the winter; humidity low during winter; (B) In basement of Lewis Institute, temperature 5-10° F. lower than (A), humidity rather high at all times; (C) In shed in yard near Laboratory; no artificial heat. The sacks were piled on the floor about 1 ft. from the ground. A roof and thin board walls protected the sacks from direct contact with rain and snow, but allowed free circulation of outside air. The conditions here were similar to those in a temporary cement storage shed erected in the field.

In general the cement was stored in lots of 800 to 1,200 lb., in standard cloth sacks; in one group of tests two brands of paper sacks were also used. In another group the cloth sack containers were covered with thin layers of (1) Portland cement and (2) hydrated lime. Tests were made at ages of 7 and 28 days, 3 months, 1 and 2 years, on samples taken immediately upon receipt from the dealers' warehouses and after storage for 3 and 6 months, 1 and 2 years.

The report includes compression tests of about 1,000 6x12 in. concrete cylinders, about 1,000 2x4 in. cylinders of 1 3 standard sand mortar, and about 500 miscellaneous tests.

The following are the principal conclusions from the investigation:

There was no essential discrepancy between the indications of the compression tests of 1-5 concrete in the form of 6x12-in. cylinders and the tests on 1-3 standard Ottawa sand mortar in 2x4-in. cylinders.

Compression tests of concrete and mortar showed a deterioration in strength with storage of cement for all samples, for all conditions and periods of storage and at all test ages. The deterioration was greeted for the samples stored in the shed in yard, and least for the samples stored in the laboratory. The basement storage was nearly as severe as outdoors. The deterioration was greater during the first 3 months than for later 3-month periods. A greater deterioration was found in the tests made at the age of 7 days than at 28 days and later test ages.

After 3-month storage in shed in yard the cement had 80 per cent of its original strength; after 6-month storage, 71 per cent; after 1-year, 61 per cent; after 2-year, 40 per cent. The deterioration was probably greater in these tests than would be found in a larger lot of cement stored under similar conditions.

The effect of storage of cement on the concrete or mortar strength is largely a question of the age at which concrete or mortar is tested. The average concrete strength of cement stored in shed in yard when tested at 7 days (for all periods of storage) is 64 per cent of the strength when received from the warehouse; at 28 days, 71 per cent; at 6 months, 78 per cent; at 1 year, 82 per cent, and at 2 years, 85 per cent. A somewhat similar relation is found for other storage conditions. It is a matter of the utmost importance to note that the strength of concrete is not permanently reduced to the low values found in the 7 and 28-day tests.

For periods up to 1½ years there was no marked difference in the quality of cement stored in cloth and in paper sacks. Two brands of paper sacks gave almost identical results.

Only a slight advantage was found from the protection of cement in cloth sacks which were covered by thin layers of Portland cement or hydrated lime. The results obtained do not justify the cost of this method of protecting cement stored in sacks.

The most favorable storage condition (in laboratory) and the least favorable (in basement and shed) gave strengths of the same order of magnitude; indicating that the possibilities of improving the storage condition of cement in sacks in this climate is rather limited. The storage period and the age of the concrete or mortar at test are of greater importance than the exact condition of storage, so long as the cement is protected from direct contact with moisture.

Storage of cement prolongs the time of initial and final setting.

The normal consistency was only slightly affected by storage.

The deterioration of cement in storage appears to be due to absorption of atmospheric moisture, causing a partial hydration, which exhibits itself in reducing the early strength of the concrete and prolonging the time of setting.

Only a negligible quantity of lumps were formed up to 1 year storage. The lumps found in the sacks after storage for more than 1 year presents a puzzling feature of such tests; they were generally discarded before testing the cement. Tests on concrete using only broken lumps as cement gave considerable strength.

This series of tests did not include bulk storage of cement, however, there is reason to believe that cement may be stored in bulk for long periods without materially affecting its concrete and mortar-making qualities.

Rise and Fall of the Bessemer Rail

The following figures, taken from Chemical and Metallurgical Engineering, are o finterest as showing in a striking way the practical elimination of the Bessemer rail.

In 1919 only 214,121 tons of bessemer rails were produced, against 1,893,250 tons of open-hearth, showing a proportion of about 9 to 1 in favor of the open-hearth. Only seven years earlier, in 1912, the proportion had been 2 to 1 for open-hearth, while in 1910 the besemer had predominated, and in 1907 the proportion had been 13 to 1 in favor of bessemer.

The 9 to 1 proportion for open-hearth in 1919 was not all the story, however, for the proportion of bessemer in the various weights was as follows:

	Gross tons, total.	Per cent Bessemer.
100 lb. and over	478,892	2.22
85-99 lb.	965,571	3.11
50-84 lb.	495,577	25.58
Under 50 lb.	263,803	17.72
Total	2,203,843	9.71

It is clear that the bessemer rail has been eliminated almost entirely for really heavy duty, i. e., for 85-lb. rails and heavier.

The supplanting of the bessemer rail appears all the more remarkable when it is recalled that for nearly a quarter of a century the chief use of bessemer steel was for making rails. Captain Robert W. Hunt gives the Kelly Pneumatic Process Co. the honor of producing the first bessemer steel made in the United States. It was blown in a 2½-ton vessel at Wyandotte, Mich., in the fall of 1864, working under American patents which post-dated Bessemer's. Alexander L. Holley and his associates were the first to bring the then new process to a commercial success, commencing operation of a 2½-ton vessel at Troy, N. Y., on Feb. 16, 1865, under the Bessemer patents which he had secured some time previous.

The first reported production of bessemer rails was in 1867, 2,277 tons. Then years later, in 18777, the bessemer rail production, 385,865 tons, exceeded the iron rail production, 296,911 tons. The production of bessemer steel ingots and castings in 1877 was 500,524 tons, so that nearly all the rolling of bessemer steel was into rails. In 1887 there was 2,936,033 tons of bessemer ingots an dcastings and 2,101,904 tons of bessemer rails, while in 1890 there was 3,688,871 tons of ingots and castings to 1,867,837 tons of rails, but 1890 was the last year in which bessemer rails surpassed all other rolled forms of bessemer steel. The wire nail, a bessemer proposition, came out in 1886 to the extent of an estimated 600,000 kegs, the next year having an estimated production of 1,250,000 kegs. In 1886 it was shown, at the Riverside works at Wheeling, that welded pipe could be made of good quality with bessemer steel. Thus for two decades anyhow bessemer steel reigned supreme as the material one should use if he wanted to make rails. When the full production statistics for 1919 become available a close estimate can be made, but meanwhile the guess may be hazarded that in 1919, while 214,121 tons of bessemer steel rails was produced, about 5,000,000 tons of other finished steel products, bars, pipe, wire, sheets, tin plate, etc., was made of bessemer steel.

Influence of Treated Timber on Annual Cross Tie Requirements*

By LOWRY SMITH,
Assistant District Engineer, Northern Pacific Ry.

The writer has prepared the chart (Fig. 1) which shows graphically the theoretical effect of the use of treated cross ties upon the annual rate of renewal. The basis of this chart is the curve shown in Fig. 3 which was presented before the American Wood-Preservers' Association in 1918 by Mabel E. Thorne, then connected with the U. S. Forest Products Laboratory, Madison, Wis. This curve shows the rate of failure of cross ties expressed in per cent for various per cents of their average life. It is compiled from the records of over 40,000 experimental ties in the United States and is the best information on the subject available. The value of it lies in that by knowing or assuming the average life for ties of a certain kind it is possible to approximate with reasonable accuracy the per cent of the total that will fail each year over the life of the entire lot.

When presenting the curve, Miss Thorne called attention to the fact that on account of the great range of variability of the properties of wood it could not be expected to be applicable to a small number of ties nor below a total failure of about 25 to 30 per cent, but that on lots of several thousand ties, enough to establish a fair average, it would give very good results.

In making the chart in Fig. 1, it was assumed that a piece of track was constructed new with ties having an average life of 7 years, which is about the average life of untreated ties throughout the United States, and that all renewals were made with such ties for a period necessary to establish a uniform rate of renewal and that from then on all renewals were made with treated ties, having an average life of 16 years.

Having assumed the average life for the untreated and treated ties reference to Fig 3 shows the approximate per cent that it will be necessary to renew each year. Assuming that a start is made with 100 per cent untreated ties, all placed in the track at the same time, the percentage that it is necessary to renew each year is tabulated horizontally. The per cent necessary to renew each subsequent year is found by taking the total of the renewal per cents appearing in the column for that year. It will be made up of a certain per cent of the ties put in each year previous to that one up to the maximum life of the ties. By following out this method and using the total per cent renewed each year as ordinates and the years as abscissas, the renewal chart was plotted.

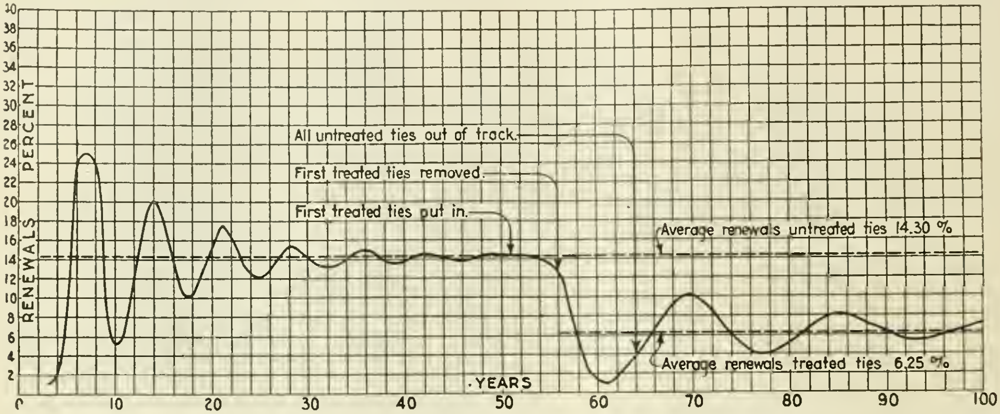

Fig. 1—Theoretical Effect of the Use of Treated Cross-ties Upon Annual Cross-tie Requirements.

Based on results from records of over 40,000 test ties in the United States, as shown in curve prepared by the Forest Products Laboratory, showing the relation between renewals and average life. Assumed in this case the use of untreated ties with average life of 7 years until stable renewal rate has been established and then making all renewals with treated ties having average life of 16 years.

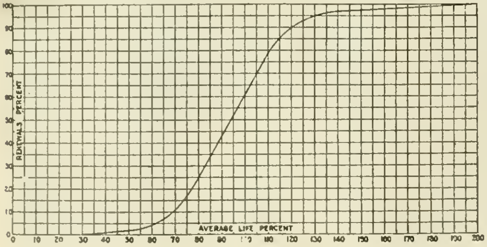

Fig. 2—Cross-tie Renewals in Relation to Average Life.

Curve prepared by the United States Forest Products Laboratory, Madison, Wis., based on records of 42,936 ties.

Figure 1 brings out some very interesting points. First is the fact that the renewals occur in cycles greater and less than the percentage representing the average rate and that as the age of the track increases the variations above and below the average grows less until eventually, in this case about 50 years, practically a uniform rate of renewal becomes established. This is the point where, for the purpose of illustration, the use of treated ties was begun and it will be noted that from there on the rate of renewlas drops off very rapidly until after about 9 years a very low rate has been reached, which increases for a time, after which it decreases and so on swinging above and below the line of average approaching closer to the uniform rate as time goes on.

Particular attention is called to this low point and the subsequent increased rate of renewal for the reason that many persons not having a true conception of what really should occur are apt to become possessed of an exaggerated idea of the benefits to be derived from the use of treated ties while the rate of renewal is dropping and an unjustified uneasiness when the low point is reached and the rate of renewal begins to increase.

It must be understood that Fig. 1 is based on purely hypothetical conditions, that all renewals are made upon the basis of actual failure and not upon any fluctuating policy brought about by change of management or state of finances, and cannot be taken as representing the actual condition as existing in any piece of track. However, it can be taken as an indication in a general way of what to expect from the use of treated ties, as has been proven by checking it against the experience of some of those who have used them for some time.

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*From a paper presented Feb. 11 at the annual meeting of the American Wood Preservers' Association.

Broader Thinking for Engineers

By P. B. M'DONALD,
Assistant Professor of English, College of Engineering, New York University.

A great deal of fault is found with the education given to students at engineering colleges. But, as the editor of Engineering and Contracting has pointed out, each individual in the long run is responsible for his own education, taking the word in the broad sense; we should never stop learning. If a man received too narrow an education while in college, he can remedy it himself by wider reading and broader thinking. Many engineers are doing this, and find that it is the secret of eternal youth, much more fascinating than keeping the nose too narrowly to the grindstone. Our age is so materialistic that we are in danger of the same disintegration that the Roman empire suffered. The romans drifted into a more and more short-sighted selfishness; they emphasized applied science to the neglect of pure science, they lost their old ideals and did not acquire new ones, and their civilization ceased to satisfy humanity. As A. J. Balfour has stated, when a civilization cease to satisfy its people, it declines; the accompanying unrest and vice are only the symptoms, not the causes of the decline.

The Roman civilization, which stretched from England to the Persian Gulf and maintained the longest period of peace that the world has ever experienced, was, of course, not the only great civilization that has declined from too much materialism and a failure of its leaders to indicate satisfying ideals to the people. John Masefield has described the condition vividly in three sonnets recently printed in Contemporary Verse. He says:

> Like bones the ruins of the cities stand,
> Like skeletons and skulls with ribs and eyes,
> Strewn in the saltness of desert sand,
> Carved with the unread record of Kings' lies.
>
> Once they were strong with soldiers, loud with voices,
> The markets clattered as the carts drove through,
> Where now the jackal in the moon rejoices
> And the still asp draws death along the dew.
>
> There at the gates the market men paid toll
> In bronze and silver pennies long worn thin,
> Wine was a silver penny for a bowl,
> Women they had there, and the moon and sin.
>
> And looking from his tower the watchman saw
> Green fields for miles, the roads, the great King's law.

Masefield is referring, it is presumed, to the old civilizations of Asia and Africa, some of which existed for much longer periods than has our present civilization, and left monuments and relics at which our archeologists marvel. The Egyptian civilization, for instance, lasted several thousand years and developed a highly specialized type of human being who did as wonderful things in the fields of knowledge that interested him as we have done in the fields that interest us. Masefield continues:

> Now they are gone with all their songs and sins,
> Women and men, to dust; their copper penny
> Of living, spent, among these dusty inns;
> The glittering One made level with the Many.
>
> Their speech is gone, none speaks it, none can read
> The pictured writing of their conqueror's march.
> The dropping plaster of a fading screed
> Seals with its mildew the decaying arch.
>
> Their fields are sand, the streets are fallen stones,
> Nothing is bought or sold there, nothing spoken,
> The sand hides all, the wind that blows it moans,
> Blowing more sand until the plinth is broken.
>
> Day in day out no other utterance falls;
> Only the sand, pit-pitting on the walls.

Such is the fate which overtakes nations that carry to extreme the policy of living only for the day, that neglect research, that substitute selfishness for ideals, and that neglect the humanities for the narrowly practical arts. While living securely in the midst of a powerful civilization, an end of it all, as pictured by the poet, seems impossible and foolishly pessimistic; but so it might have seemed to a Roman nineteen centuries ago, as he reflected on the wealth and armies and ability of the Empire that had won to its allegiance a hundred strong races of people on all sides of the Mediterranean. Masefield's concluding sonnet utters a warning:

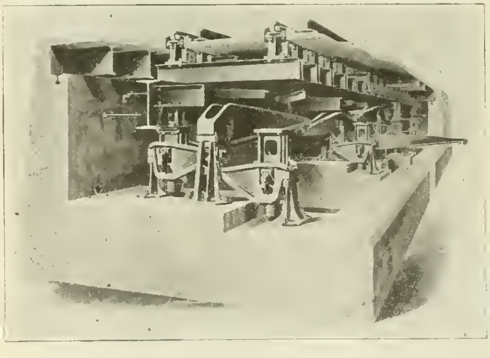
> So shall we be; so will our cities lie,
> Unknown beneath the grasses of the summer,
> Walls without roofs, naves open to the sky,
> Doors open to the wind, the only comer.
>
> And men will grub the ruin, eyes will peer,
> Fingers will grope for pennies, brains will tire
> To chronicle the skills we practiced here,
> While still we breathed the wind and trod the mire.
>
> O, like the ghost at dawn, scared by the cock,
> Let us make haste to let the spirit dive
> Deep in self's sea, until the deeps unlock
> The depths and sunken gold of being alive.
>
> Till, though our Many pass, a Something stands
> Aloft through Time that covers all with sands.

The reference to "the One and the Many" is obviously an exhortation to solve the ancient metaphysical problem that troubled the philosophers, from Heraclitus and Parmenides to the modern pragmatists and pluralists. An engineer is apt to say, "Why should I bother with philosophy; has it not been defined as a search by a blind man in a dark cellar for a black cat that isn't there?" Similarly, the Romans said, "Why should we hunt new troubles when we have our roads and aqueducts to build; of what use is abstract thought?"

There is, however, in this age of democracy and self-seeking, an obligation on each partly educated man to continue his education, to read more thoughtfully, and to think more liberally. Leaders are needed, and they can not be trained in a hurry. So practical and successful an engineer as Herbert Hoover has found time in his busy career to read voluminously in all kinds of subjects, to observe and study human nature, and to lend his mind to help solve the perplexing problems that confront the world. If the engineer has not been getting the right kind of education, he should educate himself. The country is full of libraries and opportunities for self-culture. The only condition lacking has been initiative and determination.

A New Track Scale

A new track scale embodying many new and exclusive features has been developed by E. & T. Fairbanks & Co., St. Johnsbury, Vt., manufacturers of the well known Fairbanks scales. An important feature of this scale is the departure from the use of the customary I-section levers, and the consistent use of the double web section throughout all levers of the scale.



New Track Scale of Fairbanks & Co.

In this new scale the initial load is suspended from the center of the main lever bearing, and from that point is transmitted through the true center line of the lever to each succeeding bearing. The tip of one main lever of each pair is directly over or below the true center line of the opposite lever so that the combined pull of both levers is in one straight line to the center of the bearing, which is on the center line of the longitudinal lever. The same is true at the connection of the longitudinal levers to the transverse or fifth lever.

The scale is built in four sections, with a series of primary or main levers transmitting the load to longitudinal extension levers which in turn transmit the load to a transverse extension lever which connects through a shelf lever to the beam.

It is built in two capacities for light duty service, or such service where only a relatively small number of cars are to be weighed. These two capacities are 60 tons and 75 tons per section and in lengths of 50 ft., 56 ft. and 60 ft. effective weighing rail. For heavy service or where a large number of cars are to be weighed the scale will be built in capacities of 75 tons and 100 tons per section, and in the same three lengths as above. The difference between the light duty and heavy duty scales is mainly in the loading per linear inch of knife edges, this being 5,000 lb. in the heavy duty scales and 6,000 lb. in the light duty scales. This difference in allowable loading and the allowance of a higher multiple main lever in the light duty scales serves to make somewhat lighter castings than are necessary in the heavy duty sclaes.

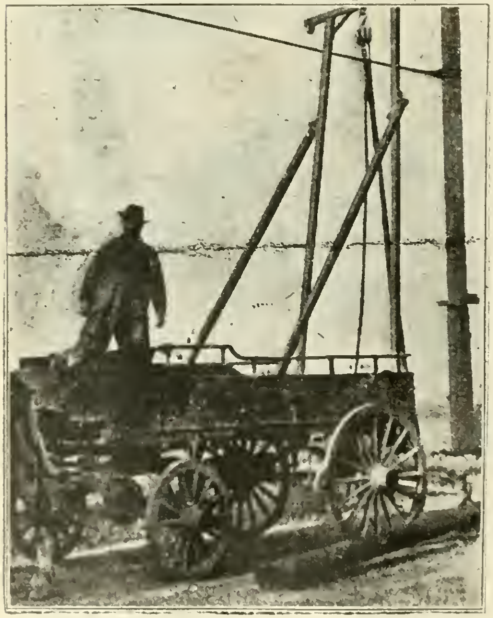
Simple Device for Raising Poles

The pole gangs of the Brooklyn Rapid Transit Co. have had added to their equipment a device which has added considerably to their efficiency. As described by Mr. G. H. McKelway in "Electric Traction," this consists simply in a strong, well-braced gallows frame erected in the rear of a 2-horse wagon, upon which frame a block and tackle can be placed for use in lifting the pole from the ground and placing it in the hole.

Before beginning to use this wagon all of the poles were set by hand, that is, with the assistance of deadmen and torks, practically all of the poles on the Brooklyn Rapid Transit system being made of steel tubing and averaging about 1,000 lb. each in weight.

The wagon used for this purpose had previously been used by an emergency crew but was no longer needed for that service as the emergency crew had been equipped with an auto truck. As the wagon was not needed for any other service and as it would bring very little if sold, it was turned over to the pole gang and equipped as shown.

The horizontal bar is carried out beyond the vertical ones a short distance so that the frame can be used as a gin pole and poles raised with it even if the wagon is not backed up to the pole, but instead parallel with it as it lies on the ground, an important point in a large city with narrow streets carrying a heavy traffic which would be blocked if the wagon had to be backed up at right angles to the curb line.

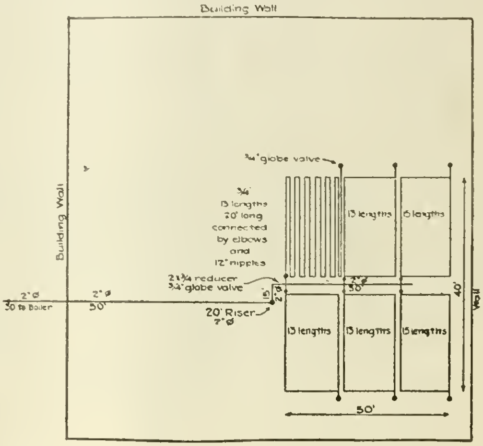


Wagon Equipped with Pole-Raising Device.

When the pole is ready to be raised the rope attached to it and running through the blocks is pulled by either the team of horses previously harnessed to the pole raising wagon or another team which has been hauling another wagon used by the same gang. This latter plan makes it unnecessary to unhitch the team from the pole raising wagon and so saves time in moving from one hole to the next as the horses are always ready to move the wagon.

Method and Cost of Thawing Ground by Steam Coils

In order to expedite the construction of an aircraft storage building at 35th street, New York City, it was necessary to devise an effective method of thawing the ground within the building so that concreting could proceed. The ground had been frozen to an average depth of some 27 in. as a result of the exceedingly cold weather that commenced the last week in December, 1917. As soon as the building was roofed and the sash glazed, an attempt was made to thaw the ground by the steam point method. This method proving somewhat ineffective, another plan was suggested by Richard T. Dana, the supervising engineer for the government. This method is described by Mr. Dana in Public Works of the Navy, from which the matter following is taken:



Layout of Piping for Thawing Frozen Ground at Navy Yard, New York.

The method proposed and adopted was as follows; the thermal tacts and general method were devised by the supervising engineer, and the excellent and most convenient arrangement of pipes was suggested by the Austin Co., with the approval of the supervising engineer:

Six units of area for thawing were arranged, each unit consisting of 13 lengths of ¾-in. pipe 20 ft. long. Each of the six units or coils had at its supply end one 2 by ¾ in. reducer and one ¾-in. globe valve and at its return end one ¾-in. globe valve, and the pipes were arranged as illustrated in the accompanying figure. By aranging the pipes in the manner shown, it was not necessary to connect and thread the pipes to the exact 20-ft. lengths, but they can be purchased as they come in the market, usually an inch or two over length. A couple of pieces of 2 by 4 in. studding 18 ft. long underneath each unit or coil is useful for moving the unit about from one completely thawed piece of ground to the next section to be thawed. It will be observed that in this manner steam is admitted to a unit of ¾-in. pipe amounting to some 260 ft. in length and containing some 72 square feet of external heating surface. These units, arranged six at a time, as illustrated in the figure, were laid directly on the frozen ground, and covered by tarpaulin separated from the pipe by 2 or 3 in., accomplished by laying 2 by 4 in. pieces of wood upon the pipe at 3 or 4 ft. intervals. A second tarpaulin was laid over the first, and separated from it by a space of 3 or 4 in. in a similar manner.

A test was made on Jan. 18 on an area of 2,000 sq. ft. and the following figures were obtained:

Area covered, sq. ft.	2,000
Depth of frost, in.	15
Outdoor temperature (average), degrees F.	27
Indoor temperature (average), degrees F.	33
Type of boiler (locomotive), hp.	70
Average steam pressure, lb.	90
Radiation:	
2-in. supply piping—	
Outdoors, 30 ft., sq. ft. surface	20
Indoors, 110 ft. (exposed to air), sq. ft. surface	75
¾-in. heating coils—	
1,721 ft., covered with paulins, sq. ft. surface	451

An efficiency test was run from 10 p. m. to 8:30 a. m., or for 10.5 hours. The results obtained were as follows:

Coal used, cu. ft.	17.5
Or approximately, tons	.4
Water used, gal.	815
At temperature (average), degrees F.	38
Condensate, gal.	680
At temperature (average), degrees F.	205
Uncondensed steam, per cent	16.5

The cost to thaw 2,000 sq. ft. was approximately as follows:

Labor:	
Firemen, at 75 ct. per hour	$18.00
Laborer to remove condensate water	8.50
Changing coils—	
1 foreman, 2 hours, at 62½ ct. per hour	1.25
7 laborers, 2 hours, at 35 ct. per hour	4.90
Total	$32.65
Coal, 0.4 ton, at $9 per ton	3.60
Cost of pipe with fittings and valves:	
1,600 lin. ft., divided by 20. (This division is an arbitrary figure, depending upon the size of the job and the number of times that the pipe can be used)	80.00

The above costs represent 24 hours' thawing or 4,000 sq. ft., from which the cost per square foot of ground to an average depth of 24 in. is 2.9 ct. The cost for labor and material per square foot of ground by the method just described was approximately one-third the cost of the steam point method and the time required was about one-fourth.

The Cause and Cure of H. C. L.*

Ordinarily the energies of contractors and engineers are so nearly exhausted in chasing H. C. L. and explosively pronouncing the term, always omitting the middle initial, they are forced to leave the cause and cure to economists and financiers. Not so Mr. Halbert P. Gillette, the brilliant editor of Enginering and Contracting, one of the foremost engineers of the country and a veritable wizard in formulas and logic. In the April 7 number of his magazine Mr. Gillette devotes 31,564 words to a quantitative, as distinguished from qualitative, analysis of the problem, arguing that economists and financiers are wrong in their views and stoutly maintaining the correctness of the following formula, deduced after a minute analysis, namely, “$W = \frac{M \times V}{P \times E}$.” Translated, this mysterious quantitative formula means that the relative average price for any given year equals the total money in circulation times the relative rapidity of the turnover, divided by the total population for that year times the per capita of production-efficiency, and has nothing to do with the yardage moved by a given contractor in a given time, or the antics of a dump car under a steamshovel.

According to Mr. Gillette, the outstanding causes of rapid price changes are two, namely, changes in the quantity of currency in circulation, which he symbolizes as M, and changes in the rate of money turnover, symbolized as V. Population, P, and per capita efficiency, E, change slowly. In the application of his formula, to determine the future, he discusses at some length the extent of change, if any, which may be looked for in these four variable factors and comes to the following conclusions:

We can look for no lowering of prices from increased productivity. The immediate future offers no hope for much lower prices as a result of increased labor efficiency; per capita efficiency and population each will increase about 1.5 per cent annually, giving a 3 per cent increase in the probable tendency to lower prices that may he expected during the next five to ten years, which, however, will be offset hy a 3 per cent annual increase in the volume of currency. This leaves only the money turnover to which we may look for relief from H. C. L., and he shows that a reduction of 20 per cent in the rate of money turnover will bring the rate back to what it was before the war. Hence 20 per cent marks the probable limit to decrease in average commodity prices for several years to come.

It should be said in passing, that Mr. Gillette's formula 'works," when applied to past records. So much for the "quantitative reasoning" of pure science. How about the "qualitative reasoning" of the financier and economist? Here is what Mr. F. A. Vanderlip, former president of the National City Bank of New York, said in a recent address in Chicago:

"The rapid upward movement of prices is due to many contributing causes, but the major cause is inflation of credit and the currency system, made possible under the federal reserve act

"The financial machinery of the country would have broken down during the war without the federal reserve system, but since the war it has been largely responsible for the increase in commodity prices. Under this act the member banks may have deposits thirty times greater than their reserves, whereas, under the old national bank act, deposits averaged only seven times greater than the cash reserves. This has made possible the rapid expansion of credit, the expansion being more rapid than the increase in the production of commodities. Therefore, more currency and credit are available for the purchase of commodities, whereas the commodity produced has no increased correspondence in volume. Inevitably, we have to pay more for the commodities we buy."

There spoke the financier. Now, let us hear what the economist has to say, none other than Mr. J. Laurence Loughlin, Emeritus Professor of Political Economy, University of Chicago: "It is not correct to say, theoretically," he declares, "that the quantity of money and the amounts of credit fix the level of prices. It is assumed that prices are kept high because much gold has come into the country, because of our favorable balance of trade, or because of an inflation of credit. In truth, the main causes of high prices are at work on the costs of production of goods and (not on gold or credit)."

Listen to his cure: "We shall reduce the cost of living only when we can reduce these increased costs of production. As soon as the countries at war get back to normal production, scarcity of food and materials will have less force in keeping up costs. Then, above all, labor must stops its impossible demands for shorter hours at higher wages, and try to join with all the factors of industry in obtaining a greater efficiency of production. If high money wages are retained, the only way by which the cost of living can be reduced is by getting an increased production and greater efficiency from those receiving the high wages."

Confidentially, the more we study H. C. L., the less we seem to know about it. What can be expected of a poor earth-mover, anyhow, when doctors disagree?

Examination for Assistant Civil Engineer, U. S. Navy.—Applications are being received at the Bureau of Yards and Docks, Navy Department, Washington, D. C., to fill 30 vacancies, more or less, in the commissioned grade of assistant civil engineer, U. S. Navy, with the rank of lieutenant (junior grade). The pay and allowances at entrance are approximately $3,200 per annum, with increases up to $9,600, depending upon length of service and promotions. The candidate must be an American citizen, between the ages of 21 and 34 years on Aug. 1, 1920; must have received a degree in engineering from a college or university of recognized standing; must have had not less than 12 months' practical, professional experience since graduation, and must be of good moral character and repute. The preliminary examination to determine general fitness will be based on papers submitted by the candidates, reaching the board on or before Aug. 23, 1920, covering college record, testimonials, references, and professional experience. The candidate is not required to report in person for the preliminary examination. Physical examination by a Board of Medical Examiners will be made of those candidates who qualify in the preliminary examination. Those who qualify in the preliminary and physical examinations will take the final oral and written examinations to be held in Washington, D. C., as soon as possible after the preliminary examination papers have been passed on by the board.

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*From The Earth Mover.

The Special Library as a Business Asset*

By H. B. MEGARGEE,
Secretary to the Vice-President, American Railways Co.,
Philadelphia.

Modern business of all kinds grows more and more highly specialized, and it is only by keeping in touch with the most advanced thought in the industry that an executive may hope to produce the best results. By constantly following up the literature which affects his business, whether it be manufacturing airplanes or selling transportation, he avoids the mistakes and takes advantage of the ideas of others.

Public utilities maintain libraries for two general purposes—welfare of employes and executive information. The former usually are connected with recreation rooms for the men, where they may go and read for profit or pleasure in the evening or while waiting for their runs. But it is with the latter that we are concerned in this instance.

The ideal arrangement is to have a central organization in charge of a librarian, whose duty it is to collect information on all matters pertaining to the various branches of the business; to mobilize data so that they may be readily available for reference to research and in addition to see that all articles of interest are brought to the attention of department heads The librarian should be an expert in his subject and the material he is handling, who will forecast areas of interest in the industry and be prepared beforehand for inquiry from the executive.

One large traction company in the state has in connection with its executive offices a library which is primarily a bureau of current intelligence. Here a librarian with assistants and clerks daily makes clippings from some 40 newspapers. Newspaper descriptions of valuable reports are followed up and copies obtained, if possible. In all cases an effort is made to get at the original source of the matter described. Periodicals received—I believe there are 60 or more of them—are scanned and articles of special interest are listed on a route sheet which is attached to the magazines, so that it reaches the members of the organization interested. Special services are performed, such as making photostats of copies of data not otherwise obtainable.

Such a system is desirable, and, to a great corporation, imperative, but for most of us it is not possible and we content ourselves with the more or less limited amount of information which comes to our personal attention. But even this may be collected into a library of incalculable value if we systematically accumulate matter in our own special field. You read an article dealing with a certain subject and are impressed with its excellence; months later this very subject comes up and it would be highly advantageous to refer to the article. You cannot remember in just what periodical it appeared. You search through your files and after much wasted time you may locate it or give up the search, with a vague regret that your memory is not better. Had you not depended on the overworked memory the time would have been saved and the worry spared.

And it is very easy to devise an accurate substitute—a card index topically arranged. The only plant required is the index and a filing cabinet. Whenever you happen upon a subject which seems to have possibilities make a note of it and have your stenographer make up a subject filing card. The card should indicate the subject heading, a brief description of the field covered and a suitable reference to the periodical. In this way you will accumulate a ready reference library which will be most useful and accessible. In addition to this, you will have your own shelves of books, and it is not possible to go into a discussion of their contents, as each individual's problem differs.

Having established your own special library, which is necessarily very limited, you will have occasion from time to time to examine other areas. The average public library will not supply the information desired, and even if it does, it takes work to "dig it out."

Some few cities have established branch libraries to render such service, but they are rare. A pioneer in the field is Mr. Dana, of Newark. Desiring to render the utmost possible service and finding that the business men did not come to his library, which was somewhat out of the way, he reached out and placed a strictly business branch in the heart of the business district. Here is to be found a skilled staff for finding or abstracting material. Men engaged in business call for chemical formulae, the transport facilities in foreign countries, the history and standing of corporations, farming conditions in western states and a thousand such queries, most of which the library is equipped to answer.

But Newark is the exception, and the need for some clearing house of special information has been so keenly felt that it has resulted in the formation of the Special Libraries Association. In most large cities we have today branches of the national association, having access to the majority of special libraries in the district. The object is to bring together all these sources into one reservoir, and this is done by indexing the subject covered by the special libraries of the members, so that if a member desires information outside of the sphere of his activities he can find it in the library of some other who makes a specialty of that particular thing, and at the same time he stands ready to perform similar service when called upon.

With such an organization standing ready to supply information on any subject and our own special library for our own particular problems we should be able to meet any contingency which may arise, and, as there is nothing new under the sun, there should be a key to every question in one or the other of them.

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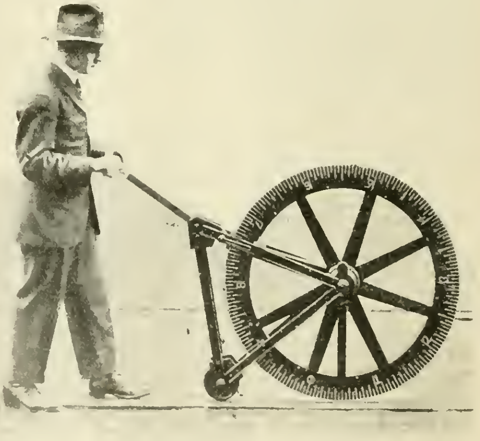
*From a paper presented May 27 before the Pennsylvania Street Railway Association.

New Device for Track Chainage

A measuring instrument that is claimed to reduce track chainage costs 60 per cent has been placed on the market by the Warren-Knight Co., 136 North 12th St., Philadelphia. This device, known as the "Sterling" Trackometer, requires one man to operate the instrument and one to make and record readings. It consists chiefly of a built-up hardwood measuring wheel with an adjustable brass tire having a true calibrated circumference of 10 ft., graduated in feet, tenths and half-tenths and numbered every foot. A strip of rubber inserted between the tire and wheel felloe furnishes the necessary resilience in adjusting the circumference, and roller bearings are used in mounting the wheel in its frame. The operating handle is hinged in the frame and may be held at any convenient height to suit the operator. The importance of the hinge feature lies in the fact that, there being no fulcrum, it is impossible to raise the measuring wheel off the rail head by bearing down on the handle. A small cast-iron trailer wheel assists in guiding the instrument along the head of the rail. A direct reading counter mounted on the frame records in feet the distance traveled, the foot subdivisions being read off the measuring wheel. A positive hand brake enabling the measuring wheel to be locked securely in any position is allied with the indicator pointer. When necessary to remove the instrument from the track before measurement is completed, to permit car or other traffic movement, the brake is applied and a keel mark made on the rail at point of indicator. To continue measurement the instrument is re-



"Sterling" Trackometer.

placed on the rail with the indicator at keel mark and brake released. The instrument can be used for track chainage, including tangent and special track work, for measuring paving yardage, and for land measurement where land is practically level.

Importance of the Nut Lock; Improvements in its Manufacture*

One of the causes of failure of mechanical joints is breakage of the nut lock or, as it is sometimes called, the lock washer. Another is the failure of the nut lock to develop sufficient reaction to prevent turning of the nut or, as will be later brought out, its failure to compensate for losses in tightness developed by bolts in service. The latter type of failure is not so pronounced when the nut locks are first installed, but there ultimately develops such a decrease in the initial tension as to render the nut lock ineffective. Breakage can generally be traced to either flaws in the metal or to too great brittleness in the metal, caused by improper heat treatment at the time of hardening and tempering. This is also the cause of failure to develop or to retain the full amount of reaction.

The nut lock itself is very small and for that reason, perhaps, track men have not given it the consideration it deserves. Its value, however, if a satisfactory nut lock can be obtained, is large. Comparatively few bolts become loose due to turning of the nuts. Obervations in a number of cases have proved conclusively that in most instances looseness occurs either because of the wear of the contact surfaces or on account of actual stretching of the bolts. It should therefore be the aim to secure a nut lock that will compensate as far as possible for this.

The process of manufacture of the nut locks must be as scientifically accurate as possible in order that the steel may assume its proper molecular structure in annealing, and in order to secure the desired degree of hardness and uniformity of temper in the heat treatments. Comparatively slight variations in the degree of heat to which they are subjected in the process of annealing before the stock is shaped into nut locks or of the subsequent heat treatment may be sufficient to render the entire lot defective.

In the manufacture of nut locks the stock is first placed in annealing ovens, where it is brought up to a specified uniform temperature and is kept at such temperature a certain time. It is then removed and permitted to cool very gradually. It is next wound into spiral coils and each individual helix is cut away by passing the coil through a special machine. The nut lock is now formed and is ready for the hardening process. In the latter it is again heated in special revolving drums, the movement of which is so regulated that it requires a certain definite time for a given number of nut locks of a given size to pass through it. The amounts of heat to which all are subjected are therefore uniform. Upon the completion of their passage through the heat chamber they are dropped into a circulating oil quenching bath, and here again the control of the temperature of the oil itself is a very important item in the process.

The next step is the tempering process. This is generally done by again heating them in air until a certain designated color test indicates to the operator that the proper temperature has been reached, when they are removed from the oven and cooled. By this method the determination of the extent of the heat treatment is entirely a matter of judgment on the part of the operator. There has recently been perfected, however, a process for tempering in an oil bath, where the control of the temperature and duration of treatment at such temperature in each bath is absolute and where the human element is entirely eliminated, thus practically assuring uniformity of temper in the finished product. The advantages of this over the first-named process are so many that it is probably only a question of a comparatively short time when all manufacturers of springs of any kind will be forced to adopt it The above outline of the processes through which the steel goes before it becomes a nut lock should aid the engineer in understanding the needs of some of the requirements in his specifications, and emphasize to him the fact that no other article used in track construction requires any greater refinements or more scientific accuracy in its manufacture than the nut lock.

The Engineer and Public Affairs*

By JOHN WILSON

Consulting Engineer, Duluth, Minn.

It is not possible to go very deeply into any of our industrial or public problems without realizing that we are treading unknown paths, are proceeding without precedent, and the magnitude of the whole situation presents itself in an astonishing manner.

As citizens of a country that was ready to fight "to make the world safe for democracy," we must admit that that same government which embodies our most cherished ideals is a dangerous government. The illiterate, the misinformed, and the man of low ideals have an equal voice with the educated, the well-informed, and the man of the highest conception of what constitutes citizenship. We come in contact every day with men of little or no knowledge, who do not hesitate one minute to set their opinion against that of men who have given their life-time to the study of the problem.

"Knowledge is power." Yes, but the entire strength of the Russian government is due to the amazing ignorance of that country.

Not only must "the world be safe for democracy," but democracy must be safe for the world, and this must be brought about by the power of knowledge prevailing over the power of ignorance.

But why bring up such a matter as this before a meeting of engineers? It is because the knowledge required and the information necessary must, to a great extent, be furnished and compiled by engineers. And just as far as the engineers fall short of doing their share and doing it well, just that far the power of ignorance will have the advantage over the power of knowledge.

The average man on completing the course in engineering completely severs his connection with the university. Such use as he may have made of the library cannot be utilized effectively in daily practice—the capacity of one's memory is too limited.

Under our present conditions, the most that can be accomplished is to cultivate a taste for technical reading and research; give the student some conception of the vast amount of organized knowledge available; and acquaint him with where such information can be found.

We believe some means could be devised whereby the wealth of information in the University library, which should include that of the Department of Economics and other, as well as the engineering library proper, could be made available to engineers. The same might be said of the laboratory facilities.

On the other hand, if the engineering library and records are to render the maximum service to the state and country they must be kept up to date and entirely abreast of the world's progress.

By proper co-operation and effective organization the engineers could contribute a vast amount of data, of which there is now so much need.

Before the engineer can contribute his full share to the country's welfare and progress, engineering must be recognized as a learned profession. However, such recognition will not be secured until the engineers themselves justify it. And this will not be until the man who prides himself on being practical takes his proper place in the ditch or on the rock-pile, and the engineer learns that research and study are not admissions of incompetency, but necessary to maintain his own standing and progress.

Nevertheless, there may be some reason for many engineers taking the erroneous position they do. The work of many of our authors, while built up on scientific principles, possibly have not been carried on to the state of maturity that it should, largely due to lack of comprehensive and accurate engineering data.

By the organization and co-operation of engineers engaged in educational work and those in active practice, the educator would be supplied with data to carry on his work to completion, the result of which, in turn, would be available for progressive application by his co-worker.

Never before have there been so many questions relative to public affairs of such vital interest to engineers, and never before have enginers been so well organized and so capable of dealing with these problems effectively.

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*From an article by Howard H. George in the "Electric Railway Journal."

*From a report presented at the 25th annual convention of Minnesota Surveyors' and Engineers' Society.

But right here a word of caution may not be out of place. Let us use our powers wisely, and not proceed too hastily with important matters.

The great work that lies before the engineer is to furnish the public with facts from which truths can be deducted, and thus aid in promoting the power of knowledge as against that of ignorance, and so advance the day when there shall be peace on earth and good will to men.

Allowances for Interest and Taxes During the Construction Period

The proper allowances to be made for interest and taxes during the period of construction were items frequently ignored in the early days of appraisals, and of late excessive figures have been used. This has been the result of a disagreement on the part of engineers, not over rates of interest and taxes, for these are fixed, but over what constituted the construction period. In a paper presented at the spring meeting of the American Society of Mechanical Engineers Mr. H. C. Anderson considers several methods that are in use to determine the length of this period, and by means of examples discusses the relative merits and shortcomings of each. He concludes that the proper interest charges can only be determined by a thorough study of the particular property under consideration with a view of determining: (1) The magnitude of the property, (2) the method used in finding the reproduction cost; (3) the proper construction period; and (4) knowing the construction period, what is the proper method to use. In determining the percentage to be allowed for taxes the author is of the opinion that the proper amount depends: (1) on the length of the construction period; (2) what percentage of the construction cost the assessor will find; and (3) the tax rate.

The paper follows:

In the early days of appraisals, interest during the construction period was frequently ignored. In some of the later appraisals it has been taken at very large figures, large because of the assumption that the construction period extended to the completion of the entire property; that is, no part of it was assumed to go into operation before the completion of the whole. There seems to be very little, if any, disagreement among engineers and commissions as to the annual rate of interest, but in many cases there is a wide variation in the length of the construction period.

If it is assumed the property is to be reproduced "piece-meal" we will have one period of construction. On the other hand, if the property is to be reproduced "wholesale" we will have a different period of construction. If a certain property is to be reproduced "piece-meal" the result would naturally be higher unit cost and lower total interest cost than if reproduced by the "wholesale" method. In some cases the two may balance.

The particular part is to fix, as accurately as possible, the construction period. Usually some part of the property, a power plant for instance, will be the best guide. Obviously, a street railway, complete in every other respect, must remain idle without power, also the question of the critical speed of construction must be given consideration. Theoretically a large property could be constructed in a few months, assuming enough men and material could be procured, but to do this it would be necessary to exceed the speed of economical construction, which would result in very high unit cost, and no doubt would more than offset the decrease in the interest cost. Consideration must be given to the question of obtaining labor and material in large quantities at the time desired, and the fact that no city would consent to the extensive tearing up of its streets that may be necessary with a short period of construction.

One method often used is to assume an interest rate of 6 per cent applied to the entire cost over one-half the construction period. The cost is zero at the beginning and is assumed to increase uniformly to the full amount at the end. The criticism often made of this method is the assumption that money can be borrowed day by day, or month by month, as needed. It is difficult to imagine bankers willing to furnish money in this way.

Another method often used is to assume an interest rate of 6 per cent and 2 per cent allowance on the unexpended balance, assuming the unexpended balance to equal one-half the loan, the loans to be made at equal intervals during the construction period. The following concrete problems will illustrate the two methods.

Problem No. 1.—Assume a property costing $12,000,000 and a construction period of three years, interest rate 6 per cent. The expenditures proceeding uniformly from zero at the beginning to the full amount at the end.

Solution: Six per cent for one-half the construction period will give a total interest charge of 9 per cent, this applied to the $12,000,000 cost will give $1,080,000 as the interest cost.

$$\frac{1{,}080{,}000}{12{,}000{,}000} = 9 \text{ per cent}$$

Problem No. 2.—Assume a property costing $12,000,000 and a construction period of three years, interest rate 6 per cent, allowance on balance at the rate of 2 per cent, balances equal one-half the load. $2,000,000 borrowed each six months.

First loan $2,000,000 at 6% for 3 yr.	$360,000	
Credit on balance, $1,000,000 at 2% for ½ yr.	10,000	
Net interest first loan		$350,000
Second loan, $2,000,000 at 6% for 2½ yr.	300,000	
Credit on balance, $1,000,000 at 2% for ½ yr.	10,000	
Net interest second loan		290,000
Third loan, $2,000,000 at 6% for 2 yr.	240,000	
Credit on balance, $1,000,000 at 2% for ½ yr.	10,000	
Net interest third loan		230,000
Fourth loan, $2,000,000 at 6% for 1½ yr.	180,000	
Credit on balance, $1,000,000 at 2% for ½ yr.	10,000	
Net interest fourth loan		170,000
Fifth loan, $2,000,000 at 6% for 1 yr.	120,000	
Credit on balance, $1,000,000 at 2% for ½ yr.	10,000	
Net interest fifth loan		110,000
Sixth loan, $2,000,000 at 6% for ½ yr.	60,000	
Credit on balance, $1,000,000 at 2% for ½ yr.	10,000	
Net interest sixth loan		50,000
Total interest for three years		$1,200,000

$$\frac{1{,}200{,}000}{12{,}000{,}000} = 10 \text{ per cent}$$

If this money is borrowed $4,000,000 each year for three years instead of $2,000,000 each six months the total interest becomes

$$\frac{1{,}320{,}000}{12{,}000{,}000} = 11 \text{ per cent.}$$

It will be noted, in this analysis, the assumption is made that no part of the money is spent until the day construction starts. In actual practice this would be very difficult, if not impossible. The land for various purposes, such as right of way, power stations, substations, shops, car houses, gas plants, commercial offices, etc., would necessarily have to be purchased one or more years before construction started. The following concrete problem will illustrate this method.

Problem No. 3.—Assume a property costing $12,000,000. Of this amount the cost of land is $1,200,000 and the structural property $10,800,000. It will require three years to obtain the land, starting one year in advance of construction. Construction period of three years. Interest rate of 6 per cent, allowance on balance at the rate of 2 per cent, balances equal one-half the loan, money borrowed each six months.

Solution: If the purchase of land starts one year in advance, and money is borrowed every six months there will be 8 periods to consider; following are the amounts borrowed each period.

	Land.	Structural property.	Total.
First period	$200,000	....	$ 200,000
Second period	200,000	....	200,000
Third period	200,000	$1,800,000	2,000,000
Fourth period	200,000	1,800,000	2,000,000
Fifth period	200,000	1,800,000	2,000,000
Sixth period	200,000	1,800,000	2,000,000
Seventh period	....	1,800,000	1,800,000
Eighth period	....	1,800,000	1,800,000
Total	$1,200,000	$10,800,000	$12,000,000

First loan, $200,000 at 6% for 4 yr.	$48,000	
Credit on balance, $100,000 at 2% for ½ yr.	1,000	
Net interest first loan		$47,000
Second loan, $200,000 at 6% for 3½ yr.	42,000	
Credit on balance, $100,000 at 2% for ½ yr.	1,000	
Net interest second loan		41,000
Third loan, $2,000,000 at 6% for 3 yr.	360,000	
Credit on balance, $1,000,000 at 2% for ½ yr.	10,000	
Net interest third loan		350,000
Fourth loan, $2,000,000 at 6% at 2½ yr.	300,000	
Credit on balance, $1,000,000 at 1% for ½ yr.	10,000	
Net interest fourth loan		290,000
Fifth loan, $2,000,000 at 6% for 2 yr.	240,000	
Credit on balance, $1,000,000 at 2% for ½ yr.	10,000	
Net interest fifth loan		230,000
Sixth loan, $2,000,000 at 6% for 1½ yr.	180,000	
Credit on balance, $1,000,000 at 2% for ½ yr.	10,000	
Net interest sixth loan		170,000
Seventh loan, $1,800,000 at 6% for 1 yr.	108,000	
Credit on balance, $900,000 at 2% for ½ yr.	9,000	
Net interest seventh loan		99,000

Eighth loan, $1,800,000 at 6% for ½ yr.	54,000	
Credit on balance, $900,000 at 2% for ½ yr.	9,000	
Net interest eighth loan		45,000
Total interest cost		$1,272,000

If this money is borrowed at the beginning of each year instead of every six months the amounts for each period will be as follows:

	Land.	Structural property.	Total.
First period	$400,000	....	$ 400,000
Second period	400,000	$3,600,000	4,000,000
Third period	400,000	3,600,000	4,000,000
Fourth period	....	3,600,000	3,600,000
Total	$1,200,000	$10,800,000	$12,000,000

The total interest cost will be $1,392,000.

$$\frac{1,392,000}{12,000,000} = 11.60 \text{ per cent}$$

I do not know of any one formula that can be applied to every type of utility, and which when solved, will give accurately the interest cost during the construction. Each property will have its own individual problems, and for this reason a thorough study should be made of the particluar property under consideration to determine:

1. The magnitude of the property and the difficulties that must be overcome during construction.
2. The method used in finding the reproduction cost.
3. The proper construction period, taking into consideration the method used in finding the reproduction cost.
4. Knowing the construction period, what is the proper method to use in finding the total interest cost?

In the end, after all theories have been considered, it is the judgment of competent engineers that should be the controlling factor.

Like interest taxes during construction is an item of cost incurred during the construction period and must be paid. The only question being, what is the proper amounts to allow. It may be argued that the value of a utility depends on its earnings, and there can be no earnings during the construction period, therefore, no taxes should be paid. But it does not work that way. The assessor finds the land and puts it on the rolls. He finds the building materials, machinery, and partly erected buildings and they also go on the rolls, perhaps not in full amount, but in some amount at least. The problem, however, is somewhat easier than in the case of interest. It is always possible to go to the company's books and find the amount of taxes the company is actually paying, also the rate, but it is not always possible to find the ratio of assessed to actual value.

It also becomes necessary to estimate just what percentage of the property under construction the assessor will find and put on the rolls. It is also necessary to consider whether the date of starting construction and the date of assessment are the same, or whether the assessment is made in mid-year of each year of the construction period. The final result will not be very different with two methods. The following problem is presented only to illustrate the solution under certain assumed conditions.

Problem No. 4.—Assume a property costing $12,000,000, of this amount the land is $1,200,000 and the structural property $10,800,000. The purchase of land is started one year before construction and continues for three years, the construction period is also three years, the assessment is made in mid-year of each construction period. The assessor will find 70 per cent of the construction cost, the rate is 2 per cent. The amount put into property each year is as follows:

	Land.	Structural property.	Total.
First year	$400,000	....	$ 400,000
Second year	400,000	$3,600,000	4,000,000
Third year	400,000	3,600,000	4,000,000
Fourth year	....	3,600,000	3,600,000
Total	$1,200,000	$10,800,000	$12,000,000

Solution:

Total cost end of first year	$400,000	
Cost at middle of first year	200,000	
Assessment at 70%	140,000	
Taxes paid first year, 2% of $140,000		$2,800
Total cost at end of second year	4,400,000	
Cost at middle of second year	2,400,000	
Assessment at 70%	1,680,000	
Taxes paid second year, 2% of $1,680,000		33,600
Total cost at end of third year	8,400,000	
Cost at middle of third year	6,400,000	
Assessment at 70%	4,480,000	
Taxes paid third year, 2% of $4,480,000		89,600
Total cost at end fourth year	12,000,000	
Cost at middle of fourth year	10,200,000	
Assessment at 70%	7,140,000	
Taxes paid fourth year, 2% of $7,140,000		142,800
Total taxes paid		$268,800

$$\frac{268,800}{12,000,000} = 2.24 \text{ per cent}$$

As in the case of interest, before the final percentage to include for taxes during construction can be determiend it will be necessary to know what method was used in finding the reproduction cost; if "piece-meal" th epercentage will be one thing, if "wholesale" it will be another. The proper amount to include for taxes finally depends on first, the length of the construction period; second, what per cent of th econstruction cost will the assessor find; third, the tax rate.

Care of Rock Drills*

By HOWARD R. DRULLARD

To obtain the best results from hammer drills, close attention must be paid to lubrication and the shank. With the exception of stoping drills, most modern rock drills require both oil and grease. Ordinary machine oil is not adapted to rock drills; a heavier more gelatinous oil, such as castor machine oil or liquid grease, should be used. Hard grease must not be put into the lubricators, as it will not flow through that part. Contrary to the popular belief, oiling a machine once or twice a shift is not sufficient; the drills should be oiled once for every 12 or 14 ft. of hole drilled. Stoping drills require oil at least twice a shift; lighter oils than castor, such as Arctic ammonia, may be used.

Drills used in shaft sinking can be oiled satisfactorily by placing a good-sized, drop, sight lubricator on the station above the sinking operations and connecting it with the air-line supplying the sinking drills. If the lubricator is properly filled and adjusted, a uniform oiling will be effected without oiling the drills individually. The grease end should be filled at the station or surface before each drilling period. The shift boss should see to it that the machines are greased and also that the lubricators at the station function properly. The life of the air-drill hose is somewhat shortened by this method, as oil attacks the inner tube, but as some oil is always present in the compressed air, this is not a serious objection.

The method of forming drill shanks on a standard drill sharpener, is simple and quite generally understood. The shanks, however, must be accurately made. A variance of ¼ in. in length will often reduce the drilling speed of the machine 25 per cent.

Close attention must also be paid to the shape and location of the hole made to accommodate the water tube. To avoid excessive breakage of water tubes, this hole must be 5/16 in. in diameter and punched to the depth of at least 3 in. It must be in the center of the steel, and after punching should be counterpunched slightly to prevent formation of a sharp edge that will cut off the water tube. The shank, of course, should present a smooth striking face.

The shank when properly formed is hardened. The operation is simple, involves no delicate judgment of temperatures or high mechanical skill, can be learned by any intelligent blacksmith in a few moments, and gives a shank so hardened that it will not batter, break, or damage the piston hammers of the rock drills.

The proper treatment of the shank begins in the forging. The steel must not be overheated; that is, it must not approach a white heat. The steel must not be allowed to "soak" in the fire, as this causes scaling; an unduly high air pressure in blowing the forge will also cause the steel to scale, and a scaled shank will not respond properly to the hardening process. After forming, the shanks should be annealed by being cooled gradually; preferably, they should be covered with lime or ashes and allowed to cool.

Either fish or linseed oil is satisfactory for hardening, althought other light oils are at times used. The quantity required is proportionate to the number of shanks to be hardened at one time. Five gallons will suffice for the hardening of three or four shanks, but if considerable steel is being worked, 45 or 50 gal. are advisable. A rectangular tank in which the steel can be stood up conveniently is generally used. The oil must be kept free from any foreign mater, particularly water.

The shank should be heated to a cherry red at the striking end with the heat graduated to a dull red just beyond the collars, or lugs; or, in the case of the shankless stoping steel, to a point about 4 in. from the end. The shank is then plunged into the oil and allower to cool thoroughly.

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*Abstract from the June Mining and Metallurgy of a paper to be presented at the Lake Superior meeting of the American Institute of Mining and Metallurgical Engineers.

Each and every shank must be so hardened that it can be readily cut with a file. The shanks must be softer than the piston hammers or damage to both will result.

Use of Wet and Dry Sand in Concrete

The U. S. Bureau of Standards has been carrying out several series of tests of concretes made from Potomac River sand and gravel, using various proportions of cement to aggregate from 1:1½:3 to 1:3:6 and with the extremes of flowability used in practical concrete construction work. The tests are summarized in a Technical News Bulletin of the Bureau. When aggregates are proportioned by volume measure, as is customary on most construction work, it is found that the use of wet aggregates requires ½ to 1 bag more cement per cubic yard of concrete than do dry aggregates. Sand is generally wet or at least moist when used, so that the full difference may never be apparent in field practice; yet the use of sand from a pile which has just been exposed to rain will result in the employment of more cement for a given volume of concrete than would have been the case had the work been done on a dry day. The excess strength resulting from the increase in cement is unnecessary providing that designed strengths were obtained with the dryer materials. As above mentioned, this increased quantity of cement may be as high as one bag per cubic yard of concrete and the increase in strength due to the added cement in a cubic yard of concrete made with wet aggregates is roughly proportional to the increase in cement. Therefore, if there is a marked increase at any time in the moisture carried by the sand, the tendency on the job should be to use larger volumes of sand in the batch.

Marked improvements in the working qualities of the concrete will be noted under usual conditions when the relative volume of sand is increased and the gravel proportionately reduced. With well-graded river sand and gravel, such as is available in the District of Columbia, the "oversanding" may be beneficial up to the point where the volume of sand in the batch is equal to the volume of the gravel. Such concrete will not segregate for maximum flowability commonly used in construction work; it will be easier working, the quantity of cement required per cubic yard will be slightly less, and there will be no reduction in compressive strength.

News Letter

St. Louis Items

The Walsh Construction Co., Davenport, Ia., was awarded the Frisco R. R. work at Oleathe, Kan. Contract includes grading, concreting and track laying. The Walsh Co. expects to place a shovel outfit on this job and will sublet the team and concrete work. I. L. Tuttle of Columbus, O., passed through St. Louis the other day on his way to Oleathe, Kan. Is figuring on subbing the concrete work from the Walsh Construction Co. at that point.

Jerry Connors will probably do the team work for the Walsh Construction Co. at Oleathe, Kan.

Scott & White, 508-510 Rialto Bldg., St. Louis, Mo., were awarded contract for six miles of Frisco Railroad cut off near Lebanon, Mo. They have 120,000 yd. of loose rock, 50,000 yd. of solid rock and 3 miles of grading suitable for a small shovel and team outfit to sublet.

Roscoe D. Smith, 54 years old, a railroad construction engineer with offices in the Third National Bank Bldg., died on May 14th. An operation for cancer of the tongue was performed several months ago. This was followed by infection. Smith was general manager of the Illinois (McKinley System) during the construction period from 1905 to 1910 and he supervised the building of the company's right of way over the McKinley bridge. His wife who survives, was Miss Helen Robb. They were married in Indianapolis in 1905.

C. E. Clark, of Clark & Jackson, took a look at some of the Frisco rock work last week. Clark is engineer for Linn county, Kansas, making his headquarters at Mound City. If some of this rock work suits him will quit the engineer job and go back to contracting.

Maj. De Witt Jones, of Washington, D. C., arrived in St. Louis to take up his duties as district engineer of the St. Louis Engineering District, relieving Maj. Wilburr Willing, who is leaving shortly to take his position as district engineer for Boston, Mass.

Will S. Cartter, formerly of the M. S. Cartter Bridge Co. but now with the Acme Operating Corporation, 11 Broadway, New York, is here on a visit. Cartter just returned from France. It has been over 8 years since his last visit here.

A. R. Gilliand has subbed the extra track work on the C. &. A. R R between Nilwood and Anderson Switch, Ill., from Mulvill Bros. Gilliand also has a 15 team outfit at work at Athens, Ill., on hard road

Nunn & Lunenschloss Construction Co., Cape Girardeau, Mo., want to hire a 15 team outfit on the drainage ditch near that point. Will let contract or do it on a percentage basis.

A contract for the construction of 12½ miles of bituminous macadam hard surface road in the Boonville Special Road District, has been let to the Pope Construction Co. of Jefferson City at a price in excess of $200,000. It is one of the largest single road contracts ever let in Missouri. Another contract will be awarded soon by the Boonville District.

Dan Terry and Ed Walsh are going to look after the Walsh Construction Co.'s new job on the Frisco R. R. at Oleathe, Kan.

The Western Tie and Timber Co., of St. Louis, has purchased the Kansas City, Ozark & Southern Ry., a short line serving the territory between Ava and Mansfield, Mo. Engineers of the St. Louis concern have been going over the line making surveys and compiling estimates.

Melon-Stewart-Nelson Co., of Pittsburgh, Pa., secured a dandy grading contract from the Aluminum Ores Co., who now own the Southern Traction Line outside of East St. Louis, Ill.

Time for completion of the St. Louis Municipal Bridge is extended three years in a bill passed June 4th by the House. The extension is from Feb. 11, 1921. Representative Igoe secured its adoption by unanimous consent. It was sponsored in the Senate by Senator Spencer.

Jime Joyce, of Cameron, Joyce & Co., reports lots of rain the past month. Says his team outfit did not move enough dirt to pay for mule feed.

Columbus S. Jones, the boss station man, landed several new station jobs last week.

List & Gifford were awarded the contract for double tracking the Frisco R. R. between Eureka and Pacific, Mo. Mike Collins will be in charge of this work.

R. T. Amis spent a couple of days here looking over the new Frisco jobs that have been let here lately with a view of subbing some of it.

Contractors when in want of labor or work for their outfits write Koenig Labor Agency, 612 Walnut St., St. Louis, Mo., 503 Delaware St., Kansas City, Mo., or 1020 Douglas St., Omaha, Neb.

R. T. Amis, of Guthrie, Okla., subbed three miles of nice team work on the Frisco Railroad near Lebanon, Mo., from Scott & White.

C. W. Marshall, Kansas City, Mo., is going to do the steam-shovel work on Scott & White's job on the Frisco R. R. near Lebanon, Mo.

P. J. Murphy, of Moberly, Mo., was awarded contract for widening banks of Wabash Railroad between Carrollton and Hardin, Mo.

The Labor Agency of A. B. Koenig in Omaha removed from 509 S. 13th St. to a more central location, 1020 Douglas St., on June 10th. B. F. Griffitts is manager A. B. KOENIG

Personals

H. G. Perring has been appointed city engineer of Baltimore, Md.

R. G. Jones has been appointed division engineer of the Mansfield, O., division of the Pennsylvania R. R.

P. T. Huntington, at present city engineer at Menomonie, Wis., has been appointed city engineer of Chippewa Falls, Wis.

K. M. Roberts, an engineer, has been appointed general manager of the Chamber of Commerce of Beaumont, Tex., at a salary of $6,000 per year.

Col. E. M. Stayton, a civil engineer of Clay county, Missouri, has been appointed a member of the board of control of the Kansas City (Mo.) Ry. Co., as representative of the city.

Harry R. Safford, assistant to the president of the Chicago, Burlington & Quincy R. R., has had the honorary degree of doctor of engineering conferred upon him by Purdue University.

Prof. C. C. Williams, of the school of engineering at the University of Kansas, will go to Europe this summer to study the transportation problems there. He will visit England, Holland, France, Belgium, Italy and Switzerland on the trip.

John Lansdale, assistant valuation engineer of the Southern Pacific Texas lines since last December, has been appointed to the position of valuation engineer, succeeding I. A. Cottingham, who recently resigned to become connected with the Houston, Richmond & San Antonio Traction Co.

Robert H. Boykin, heretofore division engineer of the Erie R. R., at Kent, O., has been appointed terminal superintendent at Jersey City, N. J., succeeding John M. Condon, promoted to superintendent of the New York division. George M. Murray succeeds Boykin as division engineer of the Kent division.

W. J. Swegman has joined the staff of J. C. Buckbee Co., engineers, First National Bank Bldg., Chicago. Mr. Swegman, a graduate of Purdue University, Class of 1906, began work with the St. Louis Portland Cement Co., following which he was engaged by the Superior Portland Cement Co., Texas Portland Cement Co., Freeborn Engineering Co., Ebro Irrigation & Power Co. of Barcelona, Spain, Hunt Engineering Co., as superintendent and mechanical engineer for the Wabash Portland Cement Co., and mechanical engineer for the Lambert Chemical & Acid Co. He returned to the Wabash Portland Cement Co. one year ago as mechanical engineer in connection with additional improvements, and having recently finished this work has joined the Buckbee organization.

Industrial Notes

Ingersoll-Rand Co. of Illinois and A. S. Cameron Steam Pump Works, Chicago branch, have changed their offices to 709 Fisher Bldg., Chicago.

The Winther Motor Truck Co., of Kenosha, Wis., has broken ground for a large addition to its present plant and it is anticipated that the new building will be completed and ready for occupancy about Aug. 30th. The new structure is 60 ft. wide by 400 ft. long. Chassis construction will still be carried on in the present plant, and the new building will be used only for final assembly, painting and inspection of Winther trucks and the Winther Six—the new passenger car.

W. T. Chollar has been appointed district manager of the Lakewood Engineering Co., New York office, to succeed George S. Hedge, who has retired from active business. Mr. Chollar's experience in the field relating to construction covers a period of nine years At the beginning of this period he became western sales manager of the Atlas Portland Cement Co. in Chicago; three years later he came east to the general office of the company in New York City to organize a department for sales promotion, with the special object of advancing the construction of concrete roads and pavements and industrial uses of concrete. After another three year period the advertising department of the Atlas Portland Cement Co was merged with the sales promotion department and Mr. Chollar was placed in charge of both as manager of what was termed the "service department."

Building and Structural Monthly Issue

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Roads and Streets—1st Wednesday
(a) Roads
(b) Streets
(c) Street Cleaning
(d) Municipal Miscellanies
(e) Management and Office System

Waterworks and Hydraulics—2nd Wednesday
(a) Waterworks
(b) Sewers and Sanitation
(c) Irrigation and Drainage
(d) Power and Pumping
(e) Management and Office System

Railways and Excavation—3rd Wednesday
(a) Excavation
(b) Management and Office System
(c) Quarries and Pits
(d) Steam Railways, Construction and Maintenance
(e) Electric Railway Construction and Maintenance

Buildings and Structures—4th Wednesday
(a) Buildings
(b) Bridges
(c) Harbor Structures
(d) Miscellaneous Structures
(e) Properties of Materials
(f) Management and Office System

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The American Federation of Labor Favors Government Ownership of Railways

By a vote of more than four to one the recent convention of the American Federation of Labor declared in favor of government ownership of railways. Samuel Gompers opposed such government ownership, but the railroad brotherhoods and the mine workers were strongly in favor of it, and carried the question.

It is a pity that economic questions of this sort are ever submitted to any convention, at least until there is submitted also a report by disinterested economists who have studied the whole matter from every angle. "Public ownership of public utilities" is a slogan that sounds well, and the average man in a convention or in a voting booth seldom goes back of the sound to the reality. Ask what American city has operated even a street railway economically, and the average voter will either have no answer or will disclose his ignorance by his reply.

If no American city has yet shown itself able to run a street railway to advantage, what likelihood is there that the federal government would be successful in the operation of railways? The editor recently put this query to a railway conductor. His reply was that he didn't care. All he cared to know was that the government had enabled him to secure a greater raise in salary than he had secured in a lifetime from the railway company. Asked whether his present salary enabled him and his family to live any better than before the war, he replied that it did not. So, in effect he thus admitted, although he did not realize it, at first, that he had been more liberally paid by the railway company prior to the war than by the government during the war.

Since federal wage boards will hereafter decide most controversies over railway wages, it is probable that the railroad brotherhoods will soon come to see that they would be no better off as to wages under government ownership than under government control. Furthermore, the appraisal of the railways will soon be completed, and then it will be clear to the railroad brotherhoods that very few railways are making exorbitant profits upon the actual value of their property. When these facts are evident to them, the railroad brotherhoods are apt to agree with Samuel Gompers that railway workers will not be permanently benefited by federal ownership of the railways.

Should the Working Day Be Shortened

The American Federation of Labor has declared in favor of a further shortening of the working day, if this be necessary to secure full-time employment of all its members. We are entirely in sympathy with the idea of providing full-time employment to all workers, but it seems to us that this should be brought about first by a shifting of workers from overcrowded industries to industries where there is a shortage of employes. Thus, it is evident that there are fully 25 per cent too many men engaged in coal mining, for, during 1918 when the coal mines were worked almost continuously, the output per miner-year was increased 25 per cent.

Rich at America is compared with other nations, a long long road must yet be traveled before the average individual is provided with all the luxuries that may be regarded as desirable. The American Federation of Labor is an organization whose primary aim is to secure a larger amount of luxuries for its members. The necessities of life are already had in abundance by nearly every American. But there is a steadily growing desire for better houses, for better clothing, for the thousand and one things that now distinguish the well-to-do from the poor. This craving for wealth should be encouraged, and the effort should be made to put within the reach of all ample opportunity to satisfy the craving. Restricting the output of workers, whether by shortening the working day or by reducing the efficiency of the workers, is not a process by which wealth is to be made universally securable.

There are, it seems to us, several important steps to be taken before any talk about shortening the working day will be wise. First, there should be devised means of preventing overcrowding of any trade or profession. Second, there should be vastly more money spent in scientific research. Third, there should be effected a great improvement in our educational system, and a systematic, part-time education should be provided for all workers for at least 10 years following their leaving school. This extension education should be largely of a scientific and practical nature.

Scientific education, research and invention constitute a wealth producing trio to which we may confidently intrust our material future. Fortunately, the American Federation of Labor is not opposed to this trio. But it is one thing to be a non-combatant and quite another thing to be militantly aggressive in behalf of a given program. The Federation has always been militant as to shorter working hours. Now that the eight-hour day is practically universal in this country, we trust that the Federation will devote as much energy toward methods that will increase the output of workers as it has hitherto devoted to securing a shorter working day.

During the past 10 years there has been no decrease in our per capita productivity, and coincidently there has been no increase in average wages when measured in buying power. Yet during the half century prior to 1909, average wages had doubled, not only in money but in the things that money secures. If we are to resume our industrial progress, with universal wealth as our goal, there must be abandonment of talk about a 35-hour week, or the like. Instead of such a program let us hear more of practical ways and means of shifting men from overcrowded to undercrowded trades. Let us hear more of applying some of the lessons learned during the war, notably the rapid vocational training of young men. Let us hear more of the spending of scores of millions of dollars annually in a scientific research. Let us exalt our scientists, our inventors and our engineers, and above all let us train our youth to a knowledge of and belief in science and scientific methods.

The Federation of Labor Becomes Socialistic

That the American Federation of Labor is fast drifting into Socialism is clearly evident in the list of "labor planks" recently published in the American Federationist. Among these "planks" are the following:

> The ownership of homes free from the grasp of exploitative and speculative interests will make for more efficient workers, more contented families and better citizens. The government should, therefore, inaugurate a plan to build model houses and establish a system of credits whereby the workers may borrow money at a low rate of interest and under favorable terms to build their own homes.
>
> Legislation should be adopted placing a graduated tax upon all usable lands above the acreage which is cultivated by the owner. Municipalities and states should be empowered to acquire lands for cultivation.
>
> Control over credit capital should be taken from financiers and should be vested in a public agency, able to administer the power as a public trust in the interests of all the people.
>
> Public and semi-public utilities should be owned, operated or regulated by the government in the interest of the public.
>
> The government should own and operate the wharves and docks connected with public harbors which are used for commerce or transportation. The American merchant marine should be encouraged and developed under government control.
>
> Legislation should be enacted providing that the governments, federal and state, should own and operate all water power over which they have jurisdiction.

It needs but a very few more "planks" of this sort to enable the Federation of Labor and the Socialist Party to coalesce completely.

The Efficacy of Fear of Discharge

Daily papers in many cities are commenting upon the fact that workers in the building trades are fast returning to a normal output per man-day. This is attributed to the relative scarcity of building construction, which has brought about a competition among workers to secure and hold jobs.

It is a pity that the average construction workman is so short-sighted that he will not do a fair day's work unless scourged to it by the fear of having no work to do. The effect of this shortsightedness is invariably a curtailment of construction until such time as many men are idle.

Socialist papers often arraign the capitalistic system on the ground that it thrives best when workers greatly exceed in number the jobs available for them. If this is true (and we doubt it), is it not quite as much an arraignment of the workers as of their employers? If workers become slackers as soon as fear of discharge vanishes, what can be said in their favor? Are they not sorely in need of education and of moral training, the former to show them their economic folly, the latter to teach them their unjustness?

We may draw another inference from the existence of a tendency to loaf on the job when the job is felt to be secure, namely, that every Socialist government will find it very difficult to make its citizens do a fair day's work. It is one of the arguments of Socialists that Socialism will remove all fear of unemployment. If so, what incentive will remain to make the average worker do a fair day's work? We believe that altruistic sentiment will prove a weak substitute for fear of individual loss or for hope of individual reward.

Thus far the great socialistic experiment in Russia has confirmed nearly all the predictions of the individualists. Russian workers refuse to do a full day's work unless knouted to their duty. But a slave of the state, as such a workman is, steadily loses efficiency.

It is true that the capitalistic system is far from being ideal, but it has at least the merit of making most men work fairly efficiently without resort to the lash.

Heat Treatment of High Chromium Steel

The experimental work in an investigation of the above subject has been completed by the U. S. Bureau of Standards, and a preliminary report covering the changes in tensile properties, hardness, and microstructure under varying thermal treatments has been submitted to the Journal of the Society of Automotive Engineers, and to Chemical and Metallurgical Engineering for publication. A summary of the results obtained is given in a Technical News Bulletin of the Bureau as follows:

Samples of high chromium steel of the following analysis, C .29 per cent, Mn. .38 per cent, Si .70 per cent, Cr 13.2 per cent, quenched in oil from various temperatures, show

(a) That hardness, as measured by Brinell and Shore instruments, increases with increasing quenching temperature until a temperature of about 1066° C. (1950° F.) is reached. Maximum range of hardness is generally obtained by quenching from this temperature, up to the highest heat used, but in some cases this hardness actually decreases, due to retention of the solid solution.

(b) That quenching from about 955° C. (1750° F.) develops the best combination of strength and ductility which is not coincident with range of maximum hardness. Quenching from this or lower temperatures does not retain all the carbide in solution, as is the case in samples quenched from considerably higher temperatures, notably 1140° to 1232° C. (2100° and 2250°F.).

(c) That ductility as measured by elongation and reduction is very low in those samples quenched from 1010° C. (1850° F.) or above.

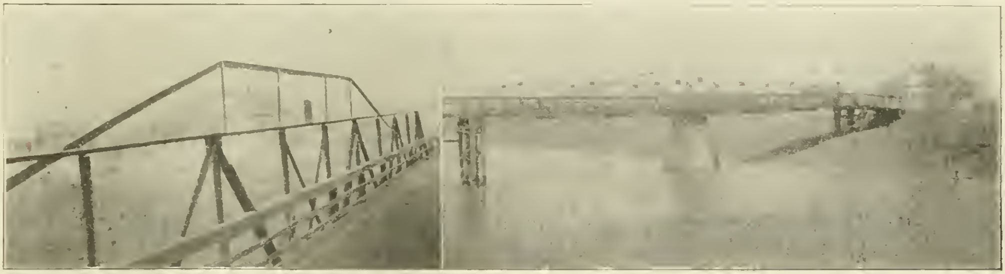
Short-time tempering at temperatures up to about 427° C. (800° F.) of samples previously quenched from both 955° and 1149° C. (1750° and 2100° F.) decreases brittleness. However, ductility is increased to a greater extent in those samples quenched from 955° C. (1750° F.) than those quenched from the higher temperatures. Tempering above 427° C. (800° F.) markedly decreases strength values and hardness, which is, of course, accompanied by greatly increased ductility. In general, the structure of the hardened steel tends to persist even when tempered for a short period of time at temperatures comparatively close to the lower critical range, the characteristics depending upon the quenching temperature used. The most rapid change in tensile properties and hardness occurs in tempering between about 427° and 538° C. (800° and 1000° F.).

Population of New York City and Chicago.—The population of New York City, according to the report of U. S. Census Bureau, is 5,621,151, which is an increase of 17.9 per cent over the 1910 figures. Chicago has a population of 2,701,212, according to the reports announced recently.

A Bridge With a Super-Superstructure

To the Editor: The advent of the motor truck and tractor has forced the strengthening of highway bridges in many cases throughout the country. I am sending you pictures of a case in Avoyelles Parish, over Bayou des Glaizes. Possibly some bridge "shark" can analyze the stresses and compute the components in this structure.

This bridge is a 150-ft. span with pier in center for opening to navigation. The reinforcement shown consists of 4 in. by ¼ in. flat bars from top chord down. Above top chord these 4-in. bars are bolted to 2-in. angles. The four vertical "members" of reinforcement are 2 in. angles.



This super-superstructure has been in place several years and so far hasn't been blown off.

L. A. SUMNER.

New Orleans, La.

Mosquito Extermination Methods at Philadelphia Navy Yard

The following account of the measures taken to eradicate mosquitoes at the Navy Yard, Philadelphia, Pa., is taken from a recent issue of Public Works of the Navy:

The work of fly and mosquito prevention in the Philadelphia Navy Yard is done by two sanitation squads of two hospital apprentices second class, and two laborers each. One of these squads is assigned to keep the eastern half of the yard in proper condition and the other the western half. A hospital apprentice is in charge of each squad, and this man is directly responsible for the conditions in the part of the yard under his care. The equipment furnished to each squad consists of three oil-spraying devices, watering pots for the distribution of niter-cake solution, necessary barrels and cans for holding oil and niter-cake solution, and a pushcart. Each squad is also furnished with two shovels, so that small amounts of ditching and filling may be done by them in an emergency.

The work of each squad is divided broadly into the treatment of the marsh land outside of the navy yard fence but on Government property, and the care of small areas of low ground in the yard; also the treatment of various artificial breeding places in the yard. On Monday and Tuesday of each week the marsh land outside the yard is treated with niter cake and oil. A 20 per cent solution of niter cake is used in this work, and in large, deep pools a quantity of the finely crushed dry material is put into the water. It has been found that putting large lumps of niter cake in the water is useless. Oil is used wherever wigglers are found in a pool, as it has been found that the oil kills the wigglers more readily than the niter-cake solution. The latter, however, appears to be very efficient in preventing the hatching of eggs, as no wigglers have been found in pools that have been treated. On Wednesdays the outlying districts of the yard proper are treated in much the same way as the marsh land lying outside. On Thursdays and Fridays the work of the squads consists of treating catch basins and other artificial breeding places. Catch basins are treated with both oil and niter cake, but oil alone is used in all vessels which would be injured by the solution. Niter-cake solution alone is sprayed around the foundations of the buildings.

An important item in this treatment of the artificial breeding places is the oiling of the bilges of the small boats stored in the yard. Oil alone is used for this purpose, it being considered that niter cake would injure the boats. On Saturday mornings both squads work on the marsh land in the eastern part of the yard in the immediate vicinity of the target butts, as at other times in the week it would be dangerous for men to work there.

When either of the above-mentioned sanitation squads find some bad condition which they are not in position to remedy, they report it to the public works officer. Such matters as breeding places caused by leaking water pipes are handled in this way. Repairs are made by the public works department. In certain cases, also, the public works department details gangs of laborers to do special jobs, such as the cutting and burning of grass and weeds outside the gate.

All ditches are cleared, and if containing stangnant water, are treated with oil or solution of niter cake. About an ounce of oil is required for 15 sq. ft. of surface, and oil must be renewed about once a week. Holes or inequalities in the ground should be filled (preferably) or treated with oil or solution of niter cake. Swampy ground should be ditched and drained.

Canadian Contractors Rated as Retailers for Tax Purposes.—According to a recent ruling of the Canadian Department of Inland Revenue, building contractors and sub-contractors, though technically manufacturers, are rated for the purposes of the new excise tax as retailers selling to the consumer. Any material manufactured by the contractor, such as metal cornices, sash and doors, must be charged by him to the owner of the building at the rate of 1 per cent sales tax. Material purchased by the contractor from a manufacturer is assessed by the manufacturer for the 1 per cent sales tax. Sales tax is chargeable on the amount of the contract between the contractor and the owner, except with respect to material manufactured by the contractor and included in his construction, such as metal cornices, sash and doors. Tax on such material to be based on selling price of such material, including labor, but not the cost of installation in the building.

Housing Conditions in United States.—Since 1916 the number of families in this country has increased 2,026,000 while in the same period the number of dwellings has increased but 637,000. The following table from the June Stone & Webster Journal shows the conditions confronting the people of the United States better than words:

Year.	Families.	Dwellings.
1890	12,690,152	11,483,318
1900	16,187,715	14,430,145
1910	20,255,555	17,895,845
1915	22,786,499	19,853,517
1916	23,292,887	20,263,051
1917	23,799,275	20,672,051
1918	24,305,662	20,808,562
1919	24,872,051	20,829,039
1920	25,319,443	20,900,000

New Housing Project at Niles, O.—The Niles Housing Co. has just been organized at Niles, O. The company is capitalized at $600,000 and is about to begin the construction of modern priced homes. Contracts are now being let for the first group of 50 or 75 houses. It is planned to build 500 as rapidly as they can be erected. The directorate is composed of nine men who are prominent in the steel industry. Edward J. Samp, formerly of Madison, Wis., has been secured as the general manager of the company.

Graphical and Mechanical Analyses of Frames

By F. E. RICHART and W. M. WILSON.

With the increasing use of rigidly connected frames and continuous beams, considerable attention has been paid by structural designers to exact methods of analyzing the stresses in such forms of construction. There are in common use a number of algebraic methods of analysis based on principles such as that of least work, the ellipse of elasticity, area-moments, slope-deflections, virtual work, the general theory of deflections, etc. However, for the rapid solution of a problem, especially for checking purposes, a method which may be applied through graphical or mechanical means is frequently desirable. Examples of such methods and a few applications are briefly presented here.

Graphical Analyses of Frames.—An excellent graphical method of analyzing continuous girders was developed in 1883 by a Scotch engineer, Fidler,[1] but it has not received much attention in American text-books on structures. The method is based on the well-known "Theorem of Area-Moments,"[2] and though developed with reference to continuous beams it may also be applied to some forms of rigid frames.

It consists in drawing positive moment diagrams for the loaded members of a frame as if each one were a simple beam, then determining by graphical construction the negative moments due to the continuity of members at the joints of the frame, and superimposing these latter moments upon the positive moment diagram.

Consider one member of a continuous frame under a given system of loads, as in Fig 1. Let the area of the positive moment diagram be denoted by F, and the distance from the centroid of this area to the left reaction by x. The end ordinates of the unknown negative moment diagram are M_A and M_B. Divide the span into three equal parts, thus locating the points C and D; at C erect the ordinate CE equal in magnitude to $\frac{2F(l-x)}{l^2}$ and at D erect the ordinate DG equal to $\frac{2Fx}{l^2}$. Fidler termed the points E and G thus located "characteristic points," and showed that the distances EF and GH (from these characteristic points to the negative moment line) are equal to the slopes of the elastic curve at A and B, respectively, times the quantity $\frac{2EI}{l}$. E represents the modulus of elasticity of the material and I the moment of inertia of the beam section.

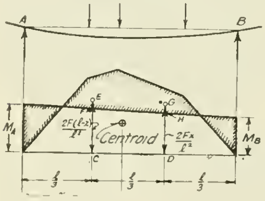


Fig. 1.

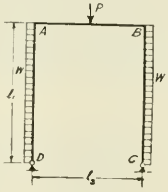


Fig. 2.

Since the elastic curves of adjacent members in a rigid frame have the same slope at their juncture the distance from the corresponding characteristic points to the negative moment line in the two members will vary directly as the respective values of $\frac{EI}{l}$. If these terms are constant the distances will be equal so that the negative moment line will pass as far above the characteristic point in one span as it does below the corresponding point in the other span.

In general this method of analysis should be applied only to frames in which the joints do not move vertically or horizontally. While such movement can be treated, it has not been done in this article. The manner of using the analysis can best be described by applying it to the solution of some definite examples of statically indeterminate structures.

Figure 2 shows a rectangular two-hinged frame under a loading which is symmetrical about the vertical center line. The procedure in determining the moments is as follows: For convenience in the graphical work, assume the vertical members swung up to the horizontal position shown in Fig. 3(a) with supports placed at A and B. (While the direct stresses differ, the bending moments are exactly the same here as they were in the original frame.) Draw moment diagrams as if each member were a simple beam. For the member DA, find the height of a rectangular diagram of length l_1 which has a statical moment about A equal to that of the simple beam moment diagram. If F is the area of the latter diagram and x the distance from its centroid to D, the required height is as shown in Fig. 3(a). Divide DA into three equal lengths and at the first one-third point plot the height just found as the ordinate to a characteristic point. At the second one-third point plot the second characteristic point which has the ordinate shown in Fig. 3(a). Similarly, at the one-third points of each member the characteristic points must be located. For uniform loads the points are at two-thirds of the maximum height of the positive moment diagram; for a concentrated center load they are at one-half of the maximum height of the positive moment diagram. Since the moments at C and D are known to be zero, it is now quite simple by a few trials to draw in negative moment lines which pass between the characteristic points at distances which vary inversely as the length of the respective spans. Considering that all areas covered by both the negative and positive diagrams are neutralized, the shaded area shows the resulting moment diagram for all points along the frame.

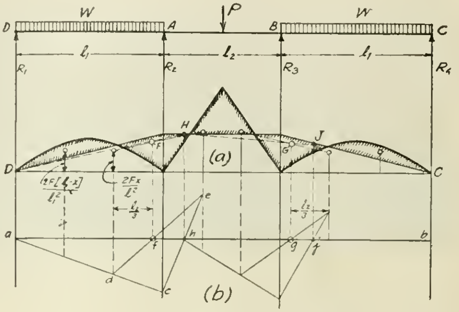


Fig. 3.

A direct construction for locating the negative moment line may be used instead of the "cut and try" method just described. Connect the nearest characteristic points in adjacent spans by straight lines. In the longer members DA and BC, lay off $1/3\ l_2$ from the 1/3 points as shown in Fig. 3(a). The intersections of vertical lines through the points just located with the lines joining the characteristic points locate the important points F and G. It is now convenient to draw Ostenfeld's[3] auxiliary diagram, Fig 3(b), starting with the line a — b and projecting the important points of the moment diagram vertically upon it. Draw any line ac

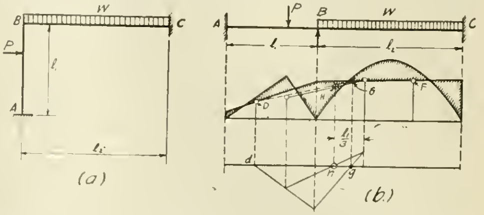


Fig. 4.

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[1] For detailed description and proof of method, see Proc. Inst. Civil Engineers, Vol. 74, p. 196, 1883, and "A Practical Treatise on Bridge Construction," by T. Claxton Fidler.

[2] See Structural Mechanics, by C. E. Greene, or Bulletin 108, Engineering Experiment Station, University of Illinois, p. 10.

[3] See Teknisk Statik, Vol. 2, 2d ed., by A. Ostenfeld, of Copenhagen. Prof. Ostenfeld devised this form of diagram in making a very general application of Fidler's method to various forms of continuous beams.

intersecting the reaction R_2 and draw de through the point f which was projected on ab from F. The intersection of ce and ab fixes a point h. Starting from h a similar construction is drawn for the next span locating the point j. The intersection of a vertical from h with a line DF locates a point H. Similarly the intersection of a vertical through j with the line HG locates a point J. H and J are points on the negative moment line, and starting from C, the line may be drawn through J, H and D, thus locating the boundary of the positive and negative moment diagrams. A rapid check is obtained by drawing a new auxiliary diagram ab, starting this time from the end b.

The direct stresses in the original frame are easily found from statics when the bending moments are known.

Further details of the method of analysis may be noted in the solution of the frame shown in Fig. 4(a). Swinging the member AB into the horizontal position for convenience, draw the positive moment diagrams, Fig. 4(b), and erect the characteristic points. Since the ends A and C are fixed, the slopes of the elastic curve at these points are zero. Hence the line of negative moments will pass through the characteristic points D and F, for the distance from the moment line to the characteristic point is proportional to the slope at the adjacent support. Locate the points H and h as indicated. Starting the auxiliary diagram at d, vertically below the point D on the negative moment line, proceed as before to locate the point g. The point G is vertically above g, and lies on a line through D and H. The negative moment line may now be drawn through F, G, and D, determining the magnitude and sign of the bending moment at all points in the frame.

The preceding examples have been analyzed on the assumption of constant moment of inertia throughout. If the moment of inertia of the different members vary as well as the length, the graphical ananlysis is most easily accomplished if the length of the members laid off is made proportional to the value of $\frac{I}{l}$ for each member. This will result in a different scale of length for the different members, but the vertical scale for bending moment will be the same for all members. With this one modification, the remaining graphical work is just as described before.

The examples given have included members with ends fixed or hinged. If the end of a member is only partially restrained, the problem can be solved providing either the moment or slope of the elastic curve at the end is known. If the moment is known, obviously this furnishes a known point on the negative moment diagram. If the end slope is known the vertical distance from the characteristic point nearest the end to the negative moment line is equal to $\frac{2EI}{l}$ times the slope. Whether this distance is to be laid off above or below the characteristic point depends upon whether the restraint is greater or less than that of a fixed end. For example, with a slope which is turned through a clockwise angle from the horizontal at the left end of a member, the corresponding distance will be plotted downward from the characteristic point. This furnishes the desired point on the negative moment line, from which to start the auxiliary diagram.

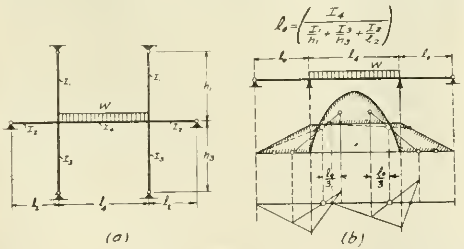
$l_0 = \left(\frac{I_4}{\frac{I_1}{h_1}+\frac{I_3}{h_3}+\frac{I_2}{l_2}}\right)$
I1
I1
h1
W
I2
I4
I2
I3
I3
h3
l2
l4
l2
(a)
l0
l4
l0
W
l4/3
l4/3
(b)

Fig. 5

Another type of frame which is sometimes used in studying moment distribution in a building is shown in Fig. 5(a). Both frame and loading are symmetrical about a vertical center line. Imagine the vertical members folded over on the outer horizontal spans. This now forms a continuous beam in which the outer spans are compound members. Lay off the distances l_4 and l_0 as indicated in Fig. 5(b) to make the initial correction for different moment of inertia and length of members. The remaining analysis is similar to that of the two preceding cases. Since there is no positive moment diagram in the first and third spans, the characteristic points lie on the base line at the third points of the members. After the bending moment diagram has been found it remains to apportion the negative moment in the outer spans among the three original members. From the theory of slopes and deflections it is known that the moment will be divided among the three members in proportion to their respective values of $\frac{I}{l}$.

Frames in which displacements of the ends of members occur through settlement or unbalanced loading may also be analyzed by this method, but involve too lengthy a treatment to come within the scope of this paper.

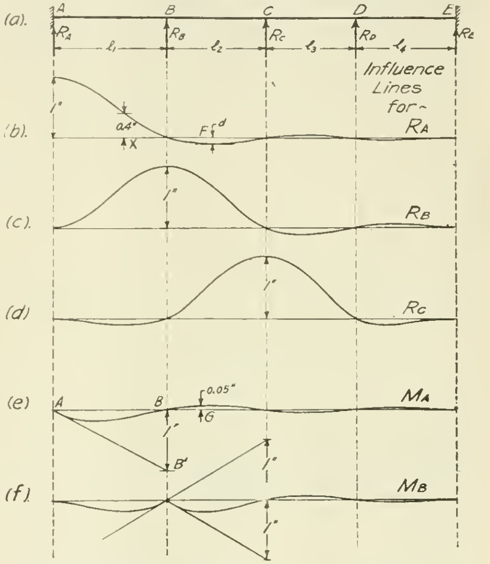

Fig. 6

Mechanical Method of Analyzing Frames.—A mechanical method of determining influence lines for the reactions of a continuous beam with overhanging ends was recently described in an article by R. Fleming.[4] The method can easily be extended to determine influence lines for reactions and moments in various forms of continuous beams and frames. The scheme is based upon the fact that the elastic curves of a beam under certain displacements are influence lines for reactions and moments. The relative magnitude of the ordinates to the elastic curve of a member may be found experimentally by use of a flexible straight edge or spline, which really is a model beam. The spline must be of uniform quality and cross-section; however, if the section of a member varies the spline should be varied accordingly.

As an example, consider the continuous beam AE of Fig. 6(a) which has four unequal spans and fixed ends. It is desired to draw influence lines for the reactions and for moments at A and B. The procedure follows: Lay the outline of the beam out to scale, locating the position of all supports. Place the spline so that its upper edge coincides with the position of the beam, and hold the ends so that their slopes remain zero. At the support A where the reaction is desired, move the spline upward a convenient unit distance, say, 1 in., holding the spline in contact at all other supports by means of pins, and keeping the slopes at the two ends equal to zero. The curve of Fig. 6(b) taken by the spline is the influence line for the reaction at A, with the scale of ordinates equal to 1 in. = 1 lb. That is, if at some point X the ordinate to the curve is + .4 in., a 1-lb. load at X will produce a reaction R_A of + 4 lb. (upward). The proof of the construction follows from Maxwell's[5] theorem of reciprocal displacement. Since the load P causing the 1-in. deflection at A causes a deflection, d, at any point, F, from Maxwell's theorem an equal load P acting upward at F would cause a deflection, d, downward at A. The reaction needed to counteract this deflection is dP divided by 1 in. Since P may have any value, say, 1 lb., the values of d at any points represent values of R_A and as drawn form an influence line for the reaction. The reactions at the other supports are found in a similar way, by moving the spline upward a unit distance at the support at which the reaction is desired, holding it in contact at all other supports, and keeping the ends fixed in direction. Fig. 6(c) and (d) show influence lines for R_B and R_C.

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[4] "Mechanical Method for Determining Reactions in Continuous Beams," by R. Fleming, Eng. News-Record, Aug. 28, 1919. Credit for devising the method is ascribed in the article to Prof. G. E. Beggs of Princeton University.

To determine the influence line for M_A, hold the spline to all other supports as before and rotate the end A until it is tangent to the line AB′, Fig. 6(e). The unit distance BB′ represents a moment of I lb. times the span l_1. For example, a load P at the point G produces a positive moment MA equal to .05 Pl_1.

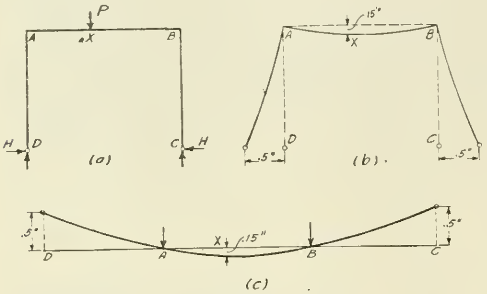

Fig. 7

The influence line for the point B, Fig. 6(f) is found in a similar way except that the spline is either cut at B, or applied successively to the positions to the left and to the right of B. As drawn, the unit ordinate represents 1 lb. times l_2, and all ordinates of the curves are expressed in terms of l_2.

As another example of the mechanical analysis of a rigid frame, consider the bent of Fig. 7(a), acted upon by vertical loads. Assume a similar bent with its column bases pushed outward .5 in. at each side, thus causing a downward deflection of the top member AB. From Maxwell's theorem it follows that the elastic curve AB is an influence line for the indeterminate reaction H of Fig. 7(a) due to vertical loads. That is, a load P applied at X, Fig. 7(a) will produce horizontal reactions H = .15P at C and D.

It can be seen that it is not necessary to have a model structure like Fig. 7(b), but that the straight edge of Fig. 7(c) will produce identical results.

Similar relations may be shown for the case of horizontal loading on the frame, but the foregoing examples should serve to illustrate the principles which must be applied. With an understanding of these principles, the solution of a problem can be performed in less time than it takes to describe it, so that the method is particularly valuable for a quick, approximate solution of this rather difficult sort of problem.

Comparative Sieve Tests of Portland Cement.—An interesting test has just been completed by the U. S. Bureau of Standards in co-operation with several other laboratories which indicates how closely the results of careful work along certain lines may be expected to check. A sample of cement was sent by the Atlas Portland Cement Co. to the Bureau and to several other laboratories with a request for a 200-mesh sieve determination in order that the results as obtained by the different laboratories might be compared. It was found that all the results were in close agreement, the extreme variation being only 0.3 of 1 per cent.

The Financial Problems of Industrial Housing*

By LESLIE H. ALLEN,
With Fred T. Ley & Co., Inc., Springfield, Mass.

The close of the year 1919 finds our industrial housing problem still unsolved. The expected fall in prices has not come and does not seem likely to come. The speculative builder seems to be definitely out of the field. Rents are still rising but have not risen high enough to show a proper return on present-day construction costs. The shortage of materials and freight cars has caused a notable increase in building costs during the past few months, so that today a house will cost 35 per cent more than it did last November. Some employers who built houses last year are using these as an inducement to attract help from other localities. Those who did not build are coming to the conclusion that they cannot hold their help without building this year, and in the meantime their production and sales are falling off because they are short of help.

Manufacturers are still hesitating and doubting the wisdom of starting their housing programs because of the fear of a financial panic or a period of depression and fall in prices. They persist in ignoring the presence of our Federal Reserve Bank which was created for the very purpose of stabilizing our financial situation. They also ignore the fact that organized labor is demanding a larger share of the returns from industry than it has received before and is going to see that it gets it.

The second difficulty is that the employer thinks he cannot rent his new house at a figure that will show an adequate financial return. It is unfortunate that the unattractiveness of the house as an investment is due to the fact that receipts from rent are usually not enough to pay a fair interest and allow for depreciation.

The rents charged were fixed many years ago; the manufacturer has not ventured to raise them to correspond with rising costs or increased wages, because of the odium that attaches to such action when the employer is also the landlord. In consequence, we find that most mills are not receiving enough rents to take care of the cost of maintenance and taxes. These low rents aggravate the housing shortage because they influence rentals and real-estate values all through the town. Other parties may get slightly higher rents, but not enough more to make property owning an attractive investment, and this discourages them even in normal times and is now an absolute barrier to real-estate development by others.

How to Calculate Proper Rental Charge.—At this point it may be well to discuss what is a proper rent for a house. Assuming a lot and a house built today cost \$6,000, of which \$500 is the cost of the lot and \$5,500 the cost of the house, the annual charges to be covered by rent would be as follows:

The prevailing interest on first mortgages is 6 per cent. Taxes vary according to locality, but a total charge of \$100 will prboahly cover taxes, insurance and water.

At the end of the 20 years the house, even after renewing the roof, heater and plumbing, will not be worth as much as its original cost. It will have depreciated through wear and tear at least 30 per cent on the first cost, the figure varying according to the quality of material and workmanship in the building and the amount of care taken of the premises by the tenant. If we assume in this case an average of 30 per cent on \$4,000 (the cost of the structure above the cellar) we obtain \$1,200 or a charge of \$60 per annum. A tabulation of these charges worked out on an annual basis follows:

Outside painting	\$100 ÷ 3	\$ 33.33
Inside painting	140 ÷ 7	20.00
Roofing	100 ÷ 20	5.00
Heater	150 ÷ 20	7.50
Plumbing	350 ÷ 20	17.50
General repairs	Average	15.00
Depreciation, at 2 per cent, on remainder of superstructure		60.00
Total maintenance and depreciation		\$158.33
Taxes and insurance		100.00
Interest on investment		360.00
Total		\$618.33

This figure, amounting to slightly over 10 per cent on the investment, does not allow anything for management. It is equal to a rent of $51.50 per month and is as low as it is safe to figure with favorable conditions. The calculations take no account of possible rise in land values or in cost of building materials which might offset depreciation.

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[5] Maxwell, C.—"On the Calculation of the Equilibrium and Stiffness of Frames." Phil. Magazine, 1867, v. 27, p. 294.

*Abstract of a paper presented at the spring meeting, St. Louis, Mo., May 24 to 27, 1920, of The American Society of Mechanical Engineers.

Methods of Financing House Construction.—The third big problem that confronts the employer in his housing problem is how to finance the large expenditure needed. The ultimate purchaser usually cannot make a large initial payment and his earnings do not permit very large monthly payments on the amount he borrows. It is very seldom that more than 10 per cent of the purchase price is offered as a first payment, and repayment of principal borrowed on mortgages is streched out by employers over periods of from 10 to (in one case) 34 years.

In most of the plans now in use the employer has to take back a second mortgage for at least 40 per cent of the total cost.

The building and loan associations of America find themselves with insufficient funds available for home buying and home building because their only source of working capital is derived from weekly cash deposits paid in by the association members.

The combination of manufacturers into a local housing corporation which shows a willingness to take the risk of building houses has proved of considerable encouragement to the prospective home purchasers. The housing corporations also gain the advantage of economical purchasing and quantity production in the erection of houses.

There are many localities where united action by manufacturers is not possible and here the employer is advised to organize his own subsidiary realty company. It is unquestionably of benefit to him that he should not be both employer and landlord.

The suggestion has been made in several quarters that new house construction should be exempt from local taxation for a period of 5 to 10 years. The benefits of this is communities where the housing shortage is very acute would at once be felt, as local taxation usually amounts to one-quarter of the rental cost of a house. It is a method often used to attract new manufacturing industries to a town and precedent for such procedure is therefore established. It may be objected, however, that the building of a number of houses adds a far greater burden to a town's expenses than an expenditure of equal amount in factory construction, as the houses usually call for an expenditure on sewers, water, etc., out of a town's funds and an additional tax on the town's school facilities, fire-protection service, police, etc. The exemption from local taxation, therefore, can only be considered an emergency measure. It is not economically sound and should be used only as a means of making all classes of a community contribute toward the relief of a town's housing shortage where other methods of enlisting their support have failed.

There is a wide difference of opinion among employers as to the wisdom of renting or selling homes to employes. The rental of houses acts as a check on the tenant leaving the factory of the company who owns the house. Rental is further necessary for young married couples not in a position to buy. The selling of houses to the workman is of advantage because the married man in his own home makes a better workman, becomes a better citizen and acquires a permanent interest in the community. For the selling scheme to be satisfactory the purchaser must be guaranteed that his investment is a liquid one. The employer must be protected if values rise and if the employe leaves his employ before the house is entirely paid for. Various plans for determining the paid-in value of the house are used which insure fairness to the workman and the employer.

A selling plan that will meet the purchaser's needs and his ability to pay is of great importance. The ordinary workman does not understand the business of home ownership, so if the selling plan is to be a success most of the thinking and planning and financing must be arranged for him. The first payment may be as low as 2 per cent, but a man worthy to purchase a house should be able to put down at least 5 per cent. Interest charges are the large item in his annual carrying charges and these will be decreased by a large initial payment. The best plan is for the man to arrange a monthly payment to take care of all outgoings and amortization of the principal.

Examples of Financing the Sale of a House.—The following examples show various methods of financing the sale of a home. It is assumed that the purchaser is earning $2,500 a year, and should be able to pay about $600 a year (or $50 a month for carrying charges and amortization). In each case the price of the house and lot is assumed to be $6,000 and the amount of the first payment $600, leaving $5,400 to be financed. Smaller or larger transactions can be figured pro rata.

The method of dealing with the mortgage finance corporations is to place a first mortgage for 50 or 60 per cent of the value and a second mortgage for the difference between that and the first payment. This would work out as follows:

First mortgage, $3,000 at 6 per cent	$180
Second mortgage, $2,400 at 6 per cent, amortized in 12 yrs	288
Taxes, insurance and water	100
Minor repairs and painting (average)	30
Total ($50 per month)	$598

When the second mortgage is amortized the workman can clear off his first mortgage in about eight years more if he continues to pay in $50 per month.

Where the purchaser's income is large enough a building and loan association mortgage for 75 or 80 per cent of the price can be taken out, and the difference between this and the first payment would have to be taken by a second mortgage. This would work out as follows:

Co-operative bank mortgage, $4,000 at 6 per cent	$240
Co-operative bank dues to amortize mortgage in 12½ years	240
Second mortgage of $1,400 at 6 per cent amortized in 12 years.	168
Taxes, insurance and water	100
Minor repairs and painting	30
Total ($65 per month)	$778

Under this method the property would be entirely paid for in 12½ years, but the monthly payments are so high that very few workmen are able to purchase in this way.

Some firms prefer to sell on a purchase agreement by which title does not pass until the house is paid for. The tenant gives a note or else land contract for the amount owing on this. He pays interest annually, and a certain minimum payment on principal, which he is encouraged to increase if possible. The advantage in this method is that a tenant is more likely to make extra efforts to pay off the principal because he sees his interest payments being reduced as often as he makes payments. In times of prosperity or high wages he can do this easily, whereas if hard times come he can reduce his annual payments to the specified minimum. The annual payments and maturity length would work out as follows:

First mortgage or purchase agreement at 6 per cent (amortized in 24 years)	$432
Taxes, insurance and water	100
Minor repairs and painting	30
Total ($47 per month)	$562

Amortization of Mortgages.—The rate of interest is such a big item in the annual cost of a house that some firms are charging less than market prices in order to help their men. One national concern is taking back a first mortgage of 95 per cent of the net cost at 4½ per cent, the principal being amortized in 30 years. At first sight it may seem that this is unbusinesslike, but the plan is undoubtedly a wise one that will benefit both parties to the deal. The difference between 4½ per cent and the prevailing interest rate represents the annual cost to the company of keeping a steady workman on the job and keeping down labor turnover and may save it several times that sum.

As labor turnover is supposed to cost from $40 for unskilled men up to as much as $250 for skilled workmen, it would seem, from this point of view, a real economy, as the loss of interest would amount to only $60 per annum.

The importance of making proper provision in any sales plan for the amortization of both first and second mortgages should be emphasized. We recognize the fact that a house will not and does not last forever, yet this fact seems to be lost sight of in the usual negotiation for mortgages. The financial difficulties of many mortgagees may be traced to the fact that mortgages placed on a conservative basis soon become very poorly secured if the mortgage debt is not reduced. Whenever a man buys an automobile he has to reduce his debt very quickly; in buying pianos or furniture on the installment basis, his repayments on principal are usually as large or larger than the amount of interest he is paying on his debt. The same idea ought to be adopted in the purchase of a house, as even the best-built house has plumbing, roofing, hardware and many other items that are wearing out. Most men will readily see the advantages of amortization. The continually reducing charges for interest and the progressive increase in repayments of principal are very attractive. With money at 6 or 6½ per cent a mortgage can be reduced very quickly on a moderate amortization payment.

Co-operative Housing.—Much interest is being shown in copartnership or co-operative housing, which is being tried in several New York City apartment houses and is the plan adopted by the English garden city companies. Under this system a company is organized to purchase and develop real estate and the stockholders are admitted as tenants to the property. The usual scheme is for each man to purchase stock to the value of half the cost of his house and land, the other half being carried by a mortgage on the whole property. His rent is sufficient to amortize the mortgage in 7 to 12 years, and then the housing company can either reduce rents or pay large dividends.

To apply this system to the housing of the working classes would necessitate the placing of blocks of stock in the hands of employers and charging enough rent to pay for the purchase of the stock by tenants from the block holders in monthly or annual installments instead of selling the whole of the stock to the tenants at the start. The rent paid would be large enough to take care of installment payments on the stock, as well as the amortization of the bonds. A rental of 12 per cent of the cost of the development would amortize the bonds and place the whole of the stock in the hands of the tenant in about 27 years.

The tenant in signing a rent agreement will acquire the right to receive annually second preferred stock to the amount of one-sixth of the rental paid, this stock being turned over to him in quarterly installments of two shares each. In addition to this he will be given one share of common stock (which carries with it voting privileges) as soon as his holdings in preferred stock reach $100, and one additional share for each additional $100 he acquires.

At the end of 25 years the whole of the second preferred stock will be in the hands of the tenants and half of the common stock will be held by them, the treasury stock being exhausted for this purpose.

In the 27th year the bonds will be entirely redeemed, and if the rent remains at the same figure there would thereafter remain $69,000 per annum available for dividends on the common stock. Probably $5 per share would be used for this purpose and the remainder carried to surplus, so that each tenant would receive $370 in dividends, viz., $245 on his preferred stock and $125 on his common stock.

The original guarantors of the preferred stock who have been holding common stock for all this time, without receiving a dividend, would receive a compensation for the risk taken in lending their credit, in the shape of $25,000 per annum dividend.

This plan has a saving incentive that would appeal to a great many workmen. Some arrangement could be made by which they could transfer from smaller to larger houses as their families increased in size.

It will be desirable to guarantee to the tenant a market for his preferred stock in case he wishes to vacate the house and leave the town, so as to remove from his mind the fear of loss which is otherwise likely to deter him from entering the scheme. It is not probable that it will be necessary to maintain this guarantee very long, as in a few years the value of the assets behind it, as the bonds are retired, will make it worth more than the purchase price.

The advantage of such a plan to the employer is that all he has to do is to guarantee an annual dividend of small amount and his funds are not otherwise tied up.

The advantage to the tenant is that he has the freedom of a tenant and yet shares the profits of the landlord and he acquires by installments a liquid investment in a housing property. He has all the rights of a householder except the speculative selling privilege, and he is relieved of the fear of loss through depreciation or forced sale.

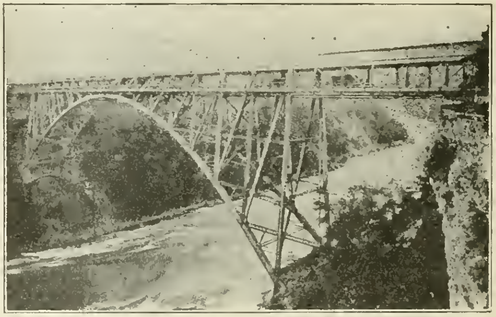
In higher-class developments where purchasers are better provided with funds, the preferred stock can be sold outright to them at the commencement, and the rental can be reduced by 2 per cent.

The plan has so many obvious merits that it is certainly worth trying out on a large scale, although it is feared that the constitutional dislike of the American workmen to any form of co-operative merchandising may prove a bar to its success.

Scientific Strengthening of Old Railway Bridge Greatly Increases Loading Capacity

As a result of a thorough overhauling, the arch carrying the Grand Trunk Ry. over the Niagara gorge has been strengthened to carry loads 62 per cent greater than those for which it was designed 22 years ago. This has been accomplished with the addition of only 600 tons of new metal, no portion of which was used to strengthen the main members of the arch structure, and the total expenditure involved is less than one-quarter of that which would have been required for the construction of a new bridge. An interesting description of this work appears in a recent issue of The Railway Age, to which we are indebted for the matter in this article.

The structure is a two-truss, two-hinged, spandrel-braced arch of 500-ft. span, flanked on either end by a 115-ft. pin-connected truss span and short lengths of steel viaduct. It carries two railway tracks on an upper deck and a highway on a lower deck with sidewalks cantilevered on either side. The railway deck carries train and switching movements aggregating some 70 or 80 trains a day.


Railroad Bridge and Gorge from American Side.

The improvement of this bridge recently completed came about as a result of an investigation made by Charles E. Fowler, consulting engineer, New York City, in 1918, at the instance of the Niagara Suspension Bridge Co., owner of the bridge, whose officers realized that it was being subjected to train loads much in excess of those for which it was designed (about E37). Not only was it desired to ascertain the capacity of the structure for the loads it was carrying, but it was also important to consider possible increases in train loadings in the future as influencing the ultimate life of the bridge.

The study made by Mr. Fowler consisted very largely of strain-gage measurements to ascertain stresses in the members of the structure under various loadings, a large part of which consisted of test trains run over the bridge under different speeds, arrangements and loads. This investigation not only disclosed the direct stresses, but the data taken were sufficiently complete to give a good idea of the secondary stresses and impact. Studies were also made to determine what loadings the bridge should be capable of carrying if it were to continue in service for any considerable period. This led to a conclusion that a loading of E-60 for the main trusses and E-70 for the floor would be adequate for many years to come.

Following this, the work of strengthening was undertaken. The new steel introduced was applied primarily in increasing the strength of the floor system, in strengthening certain members of the approach spans and the viaducts, and in providing a new system of transverse bracing in the arch. However, the crowning feature of this entire project comprised the adjustment of the arch trusses so as to relieve certain conditions of over-stress in main members and thereby obtain a structure that is entirely adequate for present day loadings.

How the Arch Was Adjusted.—The main span of the bridge was designed and built to act as a two-hinged arch for both dead and live loads. In other words, both top and bottom chords are under stress at the crown for all usual conditions of loading. Owing to unavoidable inaccuracies in erection, this condition was not obtained when the two halves of the structure (which were erected by the cantilever method) were brought together at the crown. Instead the top chords failed to come in contact by ¼ in. To overcome this defect, L. L. Buck, the designer and builder of the arch, arranged to jack the top chords apart at the crown by means of a special toggle arrangement and introduce shims 1 in. thick between the abutting ends. Another important feature in this connection was a precaution taken in the design, owing to Mr. Buck's feeling of uncertainty as to the actual behavior of the bridge, to proportion the lower or main chords of the arch for stresses that were a mean between those of the two-hinged and the three-hinged conditions. Therefore, the lower chords as built were considerably heavier than necessary for the stiffer two-hinged construction.

These two circumstances relating to the design and erection of the bridge afforded the element of reserve strength which has been utilized in the recent readjustment. Furthermore, the fact that provision had been made for jacking apart the top chords at the crown proved of value for the present purpose as will be shown hereafter.

Strain gage measurements on a completed structure under dead load are normally of value only in ascertaining the increase or decrease in stress taking place as train loadings are applied or removed from the structure. They disclose nothing as to the stresses already existing in the span as a consequence of its own weight. This is a matter of fundamental importance in an arch such as this because of the unreliability of an analytical determination of the stresses in a case where so much depends on the conditions obtaining in the erection. If, on the other hand, it is possible in any way to determine the actual dead load stress in one of the main members of the arch, this would enable computations to be completed that would disclose stresses in all the other members. This was accomplished in the Niagara arch by jacking the abutting ends of the top chords apart at the crown so that the crown panels of the top chord would be relieved of all stress. The resultant increase in their length as recorded by strain gages showed that the top chords had been relieved of a compressive stress of 689,000 lb.

Previous to this operation, various analyses had been made of the arch stresses under dead load on the assumption of different conditions of compression in this center panel of the top chord, from total stresses varying from 200,000 lb. to 1,200,000 lb. and after a careful review of the stresses in the several members of the structure under these various assumptions, it was concluded that a dead load compressive stress of 300,000 lb. in the top chords at the crown would give the most favorable conditions of stress throughout all the members of the trusses. This is about half the stress actually found to exist with the 1-in. crown shims in place. Consequently, by reducing the thickness of these shims to ⅝ in., the stress in the top chord at the crown was reduced to the amount that would give the most favorable conditions throughout. Some irregularities in stress were noted immediately after this operation was performed, but after the structure had been permitted some time in which to adjust itself under traffic, it was found that the stresses were within 6 per cent of those desired.

This was the critical feature of the entire project. With this adjustment of the dead load stresses, it was possible to load the bridge with an equivalent of E-60, with allowance for impact as obtained by the old A. R. E. A. or Pencoyd formula and certain percentages for secondary stresses, and obtain unit stresses not exceeding 20,000 lb. in tension and 19,000 lb. (less a slenderness factor) for compression. Records of tests show that the bridge had been built of steel having a yield point of 30,000 lb. per square inch.

Another factor of advantage in making this adjustment is to be found in the fact that low rivet values were used in the original design, namely, 6,500 lb. for shear. Investigations of the various joints on the basis of the increased loading showed that the rivets were not stressed in excess of 10,000 to 11,000 lb. per square inch.

The 115-ft. approach spans were also found to possess an excess of strength in the top chords on account of the extra section required when they acted as backstays for cantilever erection of the arch. The main diagonals and bottom chords were also found adequate because of the low unit stresses used in the design of these eye-bar members. The counters and the vertical web members, however, were found to need reinforcement. In the case of the counters this was accomplished by supplementing them with U-bars over the pins adjusted by turn-buckle connections. The posts were strengthened by the addition of a pair of angles and a plate (or a pair of angles alone) on the outside and inside faces, together with additional material in the arch brackets under the floor beams. To make this additional metal thoroughly effective, measures were taken to unload each of these posts with a toggle arrangement while the new angles were being riveted in place, so that when the toggles were again released the additional metal took its full proportion of the dead load stress.

Another matter closely related to the safety of the main arch structure under the heavier loadings, which was disclosed by the investigation in 1918, was the obvious weakness of the transverse bracing, indicated by excessive vibration of the structure under traffic. Some measure of correction of this feature was obtained by tuning up the cross-bracing, which consisted entirely of round rods, by adjusting them with the aid of the strain gage to a uniform stress of 7,000 lb. per square inch throughout, but when the bridge was overhauled during the past year the project included provision for new rigid bracing. The five bents of web verticals from each end of the arch were equipped either with stiff cross-bracing or with lattice trusses 10 ft. deep, while two of the main diagonals were fitted with new horizontal struts and cross-bracing composed of the rods taken from the vertical sway-bracing. The inspection also showed that a large number of the rivets were loose and as a result 11,000 rivets in various parts of the structure were replaced by new ones.

Changes in the Floor System.—In remodeling the bridge to increase its loading capacity, the most radical change was made in the floor system which naturally was affected more directly by the increased live loading than any other part. Moreover, it comprised the only portion of the structure that had suffered any appreciable depreciation. The top flange plates of the floor beams and stringers had been reduced approximately one-third by corrosion, largely the result of brine drippings, but even in the floors considerable reserve capacity was discovered in the case of the floor beams of the arch and this also was verified through the strain gage investigation.

The railway and highway floor beams together with the two web verticals of the arch trusses and the deep brackets connecting the posts to the railway floor beams formed a stiff rectangular frame affording a considerable excess of load-carrying capacity in the railway floor beams over that which would be obtained by calculating the strength of the floor beams as a simple beam between supports. While it was found that the floor beams were somewhat inadequate for E-70 loading, studies made indicated that this could best be corrected by strengthening the brackets and extending them further along the floor beams than by adding additional cover plates to the beams themselves. It was, however, necessary to add a full length cover plate to the top of the floor beams to replace the metal lost on account of corrosion.

The stringers on the arch and the 115-ft. approach spans were strengthened by the addition of top and bottom cover plates except on the American approach span and six panels at the American end of the arch where a raise of grade was introduced. Here the top flanges were strengthened by the use of a superimposed I-section that served also to raise the grade. About 65,000 rivets were cut out and redriven in the course of the work on the floor system.

Another important change made in the floor system consisted in provision for a new waterproof deck, designed to protect the steel work as well as the users of the highway against drippings from the track deck and passing trains. This construction consists essentially of a copper-steel plate covering over the floor beams and stringers, the track load being transmitted to the stringers by means of wooden shims under the ties and planks laid on top of the stringer flanges. These blocks and planks vary in thickness and are beveled.

Strengthening the Masonry.—The limestone skewbacks of the arch had shown signs of considerable weathering and were also in need of transverse stiffening. To correct these shortcomings, the entire surface of the old masonry was covered with 6 in. to 12 in. of "gunite" applied with a cement gun over wire mesh reinforcement, while a thrust wall was introduced between the two piers of each skewback. This was made 4 ft. wide and 16 ft. deep including a coping 3 ft. deep. It was amply reinforced with rods extended into holes drilled in the old masonry. The rock face of the bluffs behind the skewbacks was examined for loose rock and projecting ledges in danger of breaking off and dropping on the skewbacks if the steelwork were removed.

The abutment at the west end of the Canadian viaduct had bearings that were badly shattered. This condition was overcome by building a new pier in front of the old abutment and installing shoes for the support of the girders on the front of the old ones, the girders being equipped with new bearing stiffeners to transmit the end reaction at the new locations.

Safety Requirements for Loading Roof Trusses During Construction

The following precautions for loading roof trusses during construction are given by Mr. J. J. Rosedale, Construction Engineer, in The Architect and Engineer:

All long trusses shall be reinforced with counter and knee bracing.

No truss or roof member shall be loaded until the truss is completely bolted and all purlins and braces connected.

In the case of light trusses having no purlins, temporary struts shall be securely fastened to the top and bottom before the truss is loaded.

Concentrated loads placed during construction shall in no case exceed 3,000 lb. or 1,000 ft. b.m. of lumber.

For short trusses where the derrick or loading device can distribute the load over the entire truss, the load shall not exceed the total amount of the roof sheathing supported by the member in the finished structure.

All sheathing shall be evenly and symmetrically distributed across the entire truss with not more than one-third of the load in the middle of half the truss.

For long trusses where the derrick or loading device can not reach over the entire truss, the load shall be distributed across the middle of half the truss and shall not exceed two-thirds of the total amount of the roof sheathing supported by the member in the finished structure. The loads shall at all times be symmetrically placed.

All loads shall be evenly spread in laying the roofing on either side of the center line and unsymmetrical loading shall be avoided.

If concentrated loads are required after the roofing has been spread, they shall be placed only over the posts at the ends of the trusses.

What Is Dry Rot?

The term "dry rot," the Forest Products Laboratory finds, is applied by many persons to any decay which is found in wood in a comparatively dry situation. Thus loosely used the term actually includes all decay in wood, since wood kept sufficiently wet can not decay.

In the more limited sense in which pathologists use the term, "dry rot' applies only to the work of a certain house fungus called Merulius lachrymans. This fungus gains its distinction from the fact that it is frequently found growing in timbers without any apparent moisture supply; in reality it does not grow without moisture and is as powerless as any other fungus to infect thoroughly dry wood. Given moist wood in which to germinate, it is able to make its way a surprisingly long distance in dry timbers, drawing the water it needs from the moist wood through a conduit system of slender, minutely-porous strands.

Wood in the typical advanced stage of dry rot is shrunken, yellow to brown in color, and filled with radial and longitudinal shrinkage cracks, roughly forming cubes. In many instances these cracks are filled with a white felty mass, the interwoven strands of the fungus. The decayed wood is so brittle and friable that it can easily be crushed into powder.

The dry rot fungus is active in nearly every region of this country, in Canada, and in Europe. It is very destructive to factory and house timbers and to logs in storage. Coniferous or soft woods are more commonly infected by it than hardwoods.

Inspection of Workmanship in Concrete Construction

The making of concrete is subject to so many disturbing influences that careful inspection of all the stages and details of the process is a matter of the highest importance. Excellent suggestions for concrete inspection are given in the field manual issued by the Iowa Highway Commission for the guidance of its inspectors. The manual was prepared by R. W. Crum, Associate Professor of Experimental Engineering in Iowa State College. The matter following is taken from the chapter on inspection of workmanship.

Importance of Uniformity.—The possible quality of the concrete is determined by the tests and inspection of materials and by the theoretical considerations of proper proportioning. The actual quality depends upon inspection of the manufacture of the concrete. This quality must be uniformly maintained. The inspector's duty on the fabrication is in two parts. First, to see that proper methods are established. Second, to see that every batch of concrete is of the same quality. The first item should be taken care of definitely when the work starts. The second item will require unceasing vigilance. Concrete work cannot be considered successful unless it is uniform throughout. The uniformity of his work is the final test of a construction inspector.

The task will usually be to make sure of uniform results, using the equipment and methods of the contractor. The inspector will only have control over such methods of working as are present in the specifications. It is generally impracticable to specify both methods and results. Ordinarily, results are specified and methods left to the contractor. In concrete work there are two methods of judging results: (1) Wait till the concrete is a month old and test it. (2) Make sure that it is made right as it is being made. A good inspector will rely absolutely on the second method, but when possible should provide for a check on results by the first method. The inspector must be able to judge of the contractor's methods and make use of them unless he is sure that the proper results will not follow. He should not force his ideas concerning methods upon the contractor, but he must make sure that the methods to be used are proper before a single batch of concrete is mixed. It is evident that an inspector on any construction work will need to cultivate tact and judgment.

Storage of Materials.—Specifications usually require that sand and stone be piled on planks in order that it can be used up without scraping up dirt. This provision is important. It is especially important in road paving work, although stock piles on such work are seldom laid on planks. It is the inspector's duty to insist either upon the planks or upon wasting enough material that there is positively no admixture of dirt with the concrete. Dirt from a roadway may be extremely injurious to the concrete and must be rigidly guarded against.

Iowa Highway Commission's Proportions for Concrete.—In the field it becomes the duty of the inspector to make sure that the materials are actually used as specified. Proportions are ordinarily stated as the ratio of the parts of cement, sand, and coarse aggregate, by loose volume.

The proportions of materials for concrete for various purposes, specified by the Iowa Highway Commission, are given in Table I.

Field Practice in Proportioning Pit Run Gravel for Concrete.—When the use of pit run gravel is allowed it must be proportioned so that concrete equivalent in strength to that required of concrete made from screened materials will result. The amount of cement to use with pit run gravel depends upon the percentage of sand in the gravel, and upon the loose weight per cubic foot of the gravel. The diagrams of Figs. 1, 2 and 3 are arranged for proportioning pit run gravel concrete for three classes of concrete.

Class 1 is suitable for reinforced concrete in general, watertight work, and base course of two courses concrete pavement.

Class 2 is suitable for first class foundations, gravity section piers and abutments, base course of unreinforced floors and walks, and pavement base.

Class 3 is suitable for large foundations and heavy mass work in general.

To use the diagram, proceed as follows: First, determine the weight per cubic foot and the percentage of sand in the gravel. At the bottom of the diagram find the vertical line corresponding to the percentage of sand, at the left find the horizontal line corresponding to the weight per cubic foot. Locate the intersection of these two lines. Use the proportion shown by the sloping line passing through or near this point of intersection. If the point does not come close to one of the sloping lines use the proportion shown by the sloping line next above the point, as this will give the richer mixture of the two possibilities.

The standard specifications for proportions of pit run gravel of the Iowa State Highway Commission are given in Table II.

Three Methods of Using Pit Run Gravel.—Pit run gravel may be used in each of three different ways:

1. Enough cement may be used to make concrete of the desired class from the gravel without change.

2. The gravel may be separated into sand and coarse aggregate by screening, and then remixed in predetermined proportions.

3. The gravel may be made the equivalent of the proportion in Case 2, by adding coarse aggregate or sand as may be required.

Case 2 will yield the most uniform concrete. There is no choice between Case 1 and Case 3 on the score of uniformity. In general, the method to use will depend upon the cost.

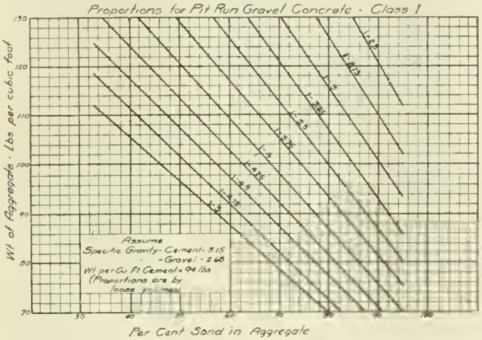


Fig. 1—Diagram for Proportioning Pit Run Gravel for Class 1 Concrete.

Comparison of Methods of Using Pit Run Gravel.—To make a comparative estimate of the costs of the three methods the following information will be required: (a) Unit prices of cement, pit run gravel, screened gravel or crushed stone, and cost of screening; (b) Quantities of materials required for 1 cu. yd. of concrete; (c) Percentage of sand in the gravel, by weight and the relative volumes of sand and pebbles a unit volume of the pit run will yield, and the weight per cubic foot of the pit run. "a" will depend upon local conditions, "b" may be estimated as shown in the Iowa Highway Commission table of proportions, "c" must be determined by test.

If a unit volume of pit run gravel be separated into two sizes it will be found that the sum of the volumes of the two sizes will be more than the original volume. For instance, 1 cu. yd. of pit run gravel may yield 0.70 cu. yd. of sand and 0.50 cu. yd. of coarse aggregate. The percentage of sand to use with the diagram for proportioning pit run materials under Case 1 may be found as follows, for the above example:

$$\text{Percentage of sand} = \frac{.70}{.70 + .50} = 58.3.$$

This figure will agree reasonably close with the percentage determined by separating the sizes by weighing. Therefore the diagrams will apply to either volumetric or weight determinations of the percentage of sand.

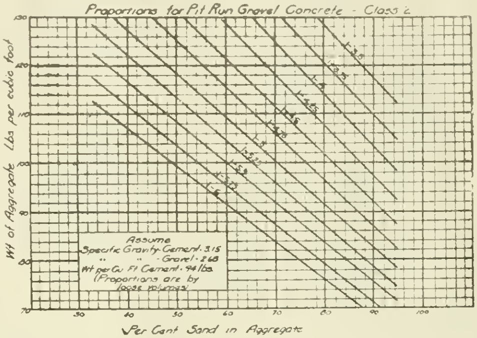


Fig. 2—Diagram for Proportioning Pit Run Gravel for Class 2 Concrete.

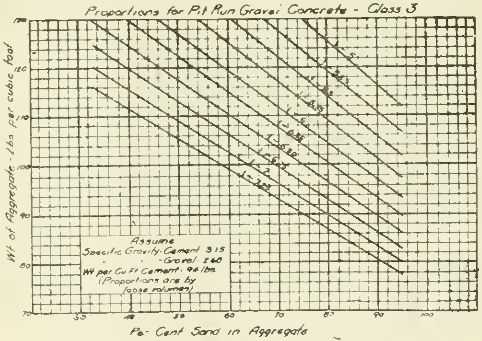


Fig. 3—Diagram for Proportioning Pit Run Gravel for Class 3 Concrete.

TABLE I—STANDARD CONCRETE PROPORTIONS, IOWA HIGHWAY COMMISSION.

Proportion.	Description.	Maximum size of aggregate. In.	Bbl. cement per cu. yd. of concrete.
1:2:4	Class A bridge concrete for concrete arch, slab and girder bridges throughout, reinforced abutments and wing walls and coping of gravity sections	1½	1.57
1:2½:5	Class B bridge concrete for body of gravity section pier and abutment	2½	1.30
1:2:3½	Class C bridge concrete for thin sections and floors of steel bridges	¾	1.68
1:1½:1½	Hand rail concrete for hand rails—all bridges	⅜	. .
1:2½	Hand rail concrete for hand rails—all bridges	¼	2.84
1:2:3½	Type A (single course) concrete pavement	2	1.60
1:2:3	Wearing course Type B (two course) concrete pavement	¾	1.70
1:2:4	Base course Type B concrete pavement	2	1.50
1:3:5	Base course monolithic brick pavement	1	....
1:2½	Dry mortar coat monolithic brick pavement	¼	....
1:1	Filler grout monolithic brick pavement	*	....
1:3:5	Concrete base for pavements	1½	...
1:2	Concrete curbing with concrete base for pavements	¼	....
1:2:3½	Concrete curb and gutter	¾	....
1:1	Cement-sand base semi-monolithic brick	¼	....

*No. 10 sieve.

TABLE II—IOWA HIGHWAY COMMISSION SPECIFICATIONS FOR PROPORTIONING PIT RUN GRAVEL.

Use.	Percentage of gravel passing No. 4 sieve.	Proportions—Cement to pit run gravel.	Quantities bbl. cement for 1 cu. yd. plastic concrete.
Class A for bridges.	Up to 55%	1 sk. to 4.0 cu. ft.	1.68
	Up to 65%	1 sk. to 3.75 cu. ft.	1.80
	Up to 75%	1 sk. to 3.50 cu. ft.	1.92
	Up to 85%	1 sk. to 3.25 cu. ft.	2.00
	Up to 95%		
Class B for bridges.	55%	1 sk. to 5.0 cu. ft.	1.37
	Up to 65%	1 sk. to 4.5 cu. ft.	1.47
	Up to 75%	1 sk. to 4.25 cu. ft.	1.57
	Up to 85%	1 sk. to 4.00 cu. ft.	1.66
	Up to 95%	1 sk. to 3.75 cu. ft.	1.79
Base course monolithic brick and other types of pavements	42%	1 sk. to 7.00 cu. ft.	1.00
	Up to 55%	1 sk. to 5.5 cu. ft.	1.25
	Up to 65%	1 sk. to 5.0 cu. ft.	1.35
	Up to 75%	1 sk. to 4.5 cu. ft.	1.50
Curb and gutter....	42%	1 sk. to 4.5 cu. ft.	1.52
	Up to 55%	1 sk. to 4.0 cu. ft.	1.68
	Up to 65%	1 sk. to 3.75 cu. ft.	1.80
	Up to 75%	1 sk. to 3.50 cu. ft.	1.92

Having the above information, proceed as follows: (1) From the diagram derive the proportion of cement to gravel to use for Case 1. (2) Assume the proportion of cement to sand to coarse aggregate which would be the equivalent to the above mixture for Case 1. (For Class 1 concrete use 1:2:4; Class 2 use 1:2½:5; Class 3 use 1:3:6). (3) Compute comparative costs.

Example: Prices—	
Cement	$2.00 per bbl.
Pit run	1.00 per yd.
Stone	2.00 per yd.
Screening	.50 per yd.
Percentage of sand in gravel	58.0 by weight
Yield of sand	.70 of volume of pit run
Yield of sand	.50 of volume of pit run

Case I—Using pit run straight.

Proportions required for Class 1 concrete from Table II is I to 4.

For one yard of concrete.

Material required—cement	1.68 bbl.
(From Table II) pit run	1 yd.
1.68 bbl. at $2.00	$3.36
1 yd. pit run	1.00
Material cost	$4.36

Case 2. Screening and remixing to make the proportions 1:2:4.

Material required...... 1.50 bbl. cement
(From Table I)
.44 cu. yd. sand
.88 cu. yd. pebbles

A cubic yard of gravel will yield about .70 cu. yd. of sand and .5 cu. yd. pebbles.

To produce 0.88 cu. yd. of pebbles it will be necessary to buy and screen $\frac{.88}{.5} = 1.76$ cu. yd. of pit run gravel.

Cost of material is therefore:

1.5 bbl. cement at $2	$3.00
1.76 yd. pit run at $1	1.76
1.76 yd. screening at 50 ct	.88
	$5.64

Case 3. Adding coarse material to make the proportion 1:2:4 as before

Material required...... 1.5 bbl. cement
.44 cu. yd. sand
.88 cu. yd. gravel

One yard gravel will yield about .70 cu. yd. of sand.

Therefore to produce .44 cu. yd. sand $\frac{.44}{.70} = .63$ cu. yd. of pit run will be required.

.63 yd. pit run will yield .44 yd. sand and .31 yd. stone, leaving .88 — .31 = .57 yd. stone to be added.

Cost—

1.5 bbl. cement at $2	$3.00
.63 yd. pit run at $1	.63
.57 yd. stone at $2	1.14
	$4.77

In Case 2 it will be noted that considerable sand will be left over. If there is a market for this sand the amount should be computed in a similar manner and its value deducted from the total cost of the materials.

Correcting Proportions for Excess Fine or Coarse Material.—Specifications usually require that the sand shall all pass a No. 4 sieve and that the coarse aggregate shall all be retained on the No. 4 sieve, or certain limits may be set for an allowable amount of over size sand or under size coarse aggregate. When the materials supplied fall within the specification the inspector's duty is simply to see that they are used in the proportions specified. When the materials contain more over or under size particles than is allowable, and it is allowable to use such material, it is necessary for the inspector to define the proportions in which two materials shall be mixed so that the mixture wwill have the relation between sand and coarse aggregate specified. The computation can best be illustrated by an example.

Information required:
- Specified proportions.
- Percentage of sand larger than No. 4 sieve.
- Percentage of coarse aggregate finer than No. 4 sieve.
- Loose weights per cu. ft. of material as supplied.

Example:
- Proportions specified 1:2:4 by volume.
- Sand coarser than No. 4 sieve 3% by weight.
- Coarse aggregate finer than No. 4 sieve 15% by weight.
- Weight per cu. ft. sand, 98 lb.
- Weight per cu. ft. coarse aggregate, 112 lb.

Inasmuch as weight relations are definite and fixed while volumetric relations are variable, the problem must be worked on a weight basis and the proportions so determined afterward converted to a volumetric relation for field use.

(1) Change the volumetric proportion 1:2:4 to the corresponding relation by weight, by substituting the weight per cubic foot of the different materials.

94:2 × 98:4 × 112 = 94:196:448 = 1:2.085:4.77 = 1:6.8555 total aggregate proportion by weight.

(2) In the proportion specified, the sand portion of the aggregate $= \frac{2.085}{2.085 + 4.77} \times 100 = 30.5$ per cent by weight and the coarse aggregate $= \frac{4.77}{2.085 - 4.77} \times 100 = 69.5$ per cent.

This means that 30.5 per cent of the mixed aggregate must pass a No. 4 sieve. The problem is simply to so proportion the aggregates supplied that 30.5 per cent of the mixture will pass the No. 4 sieve.

Let x = the part of sand to use.
Let y = the part of coarse aggregate to use.
By weight, $x + y = 1.0$.
95% of the sand passes the No. 4 sieve.
15% of the coarse aggregate passes the No. 4 sieve.
$95x + 15y$ must equal 30.5.
Solving for x and y—.

$$\begin{aligned} x + y &= 1. \\ 95x + 15y &= 30.5 \\ 95x + 95y &= 95.0 \\ \hline 80y &= 64.5 \\ y &= .806 \\ x &= .194 \end{aligned}$$

Therefore 19.4 per cent of the mixed aggregate must come from the sand as supplied and 80.6 per cent of the mixture must come from the coarse aggregate as supplied.

The parts of total aggregate to 1 part of cement in the specified proportion are 6.85.

19.4 per cent of 6.85 = 1.33.

80.6 per cent of 6.85 = 5.53.

Therefore the proportion in which to use the materials supplied is 1:1.32:5.53 by weight.

Change this relation to the volumetric relation as follows:

Multiplying by 94 = 94:124:520.

Divide by the weights per cubic foot.

$$\frac{94}{94} : \frac{124}{98} : \frac{520}{112} = 1 \cdot 1.26 : 4.64.$$

The nearest practicable proportions would be 1:1¼:4¾.

This mixture as shown would be equivalent to the 1:2:4 mix specified.

The special methods of measuring materials are not important so long as the correct amounts are always put in each batch.

Measuring Cement.—The most convenient as well as accurate method of measuring cement is by even bags as packed by the manufacturer. The net weight of a bag of cement is required by the A. S. T. M. standard specifications to be not less than 94 lb. and of course will seldom exceed that amount since cement is sold by the bag. Therefore a bag of cement is a very definite quantity and is commonly specified to be the equivalent of 1 cu. ft. It is by far the best practice to use a size of batch requiring an even number of bags. An experienced man can divide a bag into halves with a reasonable degree of accuracy, but any further subdivision should not be allowed, unless it is done by direct weighing.

Cement delivered in bulk should only be weighed. Loose measurement of cement, due to its flour-like nature is a very uncertain quantity, and the desired degree of uniformity cannot be secured by this method of measuring. There are automatic devices on the market for measuring bulk cement. The use of such devices should only be permitted subject to the approval of the engineer. The useful field for the use of bulk cement shipped in box cars is when the location is such that the cars can be spotted close to the mixing plant. There is no insuperable obstacle to the weighing of the cement. A platform scale can be easily introduced into the cement runway and the amount carried in the wheelbarrow corrected without delaying the mixer.

Measuring Aggregate.—Sand and coarse aggregate are commonly proportioned by loose volume, and are therefore usually measured in a corresponding manner. The most accurate method of securing uniform measurements is by weight, although if the moisture in the aggregate varies from time to time even this method is not absolutely uniform unless a correction is made for the amount of moisture present.

In making loose volumetric measurements it is absolutely essential for uniformity, that the measure be always filled in the same manner. All granular materials vary greatly in the weight of a unit volume, depending upon the degree of compactness in the measure.

The best method of making loose volumetric measurements is by means of measuring boxes of definite capacity. Where bottomless boxes can be used to advantage, they are very satisfactory. The use of any other type of measure except wheel-barrows usually involves an extra handling of the material, which of course adds to the expense. Nevertheless on work requiring extremely high quality the use of the best possible method of measuring should be seriously considered.

The almost universal method of measuring aggregates is by wheelbarrow loads. Uniform results can be secured with such measurements if the inspector pays close attention to this step in the process. There are three ways in which such measurements may be handled.

(1) The requirement may be made that the load shall be struck off with a templet of the right shape to make the load the right size for the batch. This procedure is very good, but it will not work satisfactorily to both parties unless the size of the wheelbarrows on the job is such that the wheelers will work to capacity. It will take more men to keep a mixer working, wheeling 1½ cu. ft. loads, than it will be if the loads are 2½ cu. ft.

On a level plank runway 3 cu. ft. is a fair load. On an incline the load would need to be decreased to 2½ or 2 cu. ft. If the struck wheelbarrow would give the appropriate maximum load this method should be satisfactory. It is to the interest of the inspector that the men should carry maximum loads as any tendency on the part of the wheelers to change the load would be to lessen the load and thereby increase the quality of the concrete. It should be understood that possible advantages in handling concrete should be on the side of improved quality in the concrete.

(2) When the size of wheelbarrow and maximum load is such that the unit of measurement may be made a heaping wheelbarrow load on which no more material will stand, there is no danger of the measurement of aggregate being too large. This is a good system to use, provided that a proper relation of loads of aggregate to full or half bags of cement can be established.

(3) After investigating the possible use of the methods (1) and (2), if the size of the load must be intermediate between the struck load and the heaping load, proceed as follows: Decide upon the number of cubic feet per load, then using a cubic foot box load a wheelbarrow to establish the size of the load. Call the attention of the shovelers to this load and make it understood that every load shall be of this size. Wheelbarrows can be loaded in this way, with a fair degree of accuracy if the standard load is frequently established. At intervals of from 30 minutes to one hour the inspector should repeat the operation of standardizing the load. A very good way to help maintain the proper size of load is to paint a strip around the sides of the barrow on the inside, marking the level to which it shall be filled.

Moisture in Sand.—The presence of moisture in sand will lessen the net weight of a unit volume, from that of a unit volume of dry sand. As proportions are based upon dry materials it follows that if the sand is wet a cubic foot will really contain less sand, and therefore when the proportions are measured, the concrete will be slightly richer than the specifications require. It is not customary to make an allowance on this account. The size of the load is generally kept the same irrespective of moisture content. Damp sand will stand at a steeper slope than dry sand, and unless the loads are carefully watched there will be tendency to overloading.

Measuring Water.—It is absolutely necessary that the consistency of concrete be maintained as established. To do this requires definite measuring of water. Any arrangement that will assure the admission of a definite amount of water into the mixer, and that can be closely adjusted for variations in conditions, will do. Running the water in through a hose or pipe, by which the quantity for each batch is left to the judgment of the operator should not be allowed. Modern experience has demonstrated beyond a doubt the extreme importance of keeping the amount of water at a reasonable minimum, and also the importance of maintaining a uniform consistency. Mixers are often equipped with automatic devices for measuring the water. The inspector should satisfy himself that such device will deliver the right amount of water per batch. Devices that automatically dump the entire contents of a tank and no more are ordinarily satisfactory. Devices that depend upon automatically shutting off the flow after a time interval may be satisfactory or not depending upon whether there is a constant pressure upon the water line. Every time the pressure changes in such an arrangement, the amount of water flowing in a given time will be changed. The inspector must realize, that after the consistency is properly gaged, the addition of only one quart of water will make a very appreciable change in the quality of his concrete.

If the materials were always dry, or, during a job, carried always the same amount of water, the amount of water per batch could be established at the start and used without change so long as the same materials were supplied. However, when materials are stored in the open there are bound to be variations in moisture content, and it is the duty of the inspector to keep track of these variations and order the appropriate changes in the amount of water.

Time of Mixing.—It is important that the materials for concrete be thoroughly mixed. Appearance of the concrete is not an accurate measure of thoroughness of mixing. The only way to be sure is to know that the mixing period after all the materials are in the mixer is long enough. A mixing period of one minute at a speed of from 12 to 16 revolutions per minute may be considered good pratice. This means 1 minute, net, after all the materials are in the mixer and before any of the concrcete is drawn out. Longer mixing is slightly beneficial, but is of doubtful efficiency.

The following quotation from a paper entitled "Effect of Time of Mixing on the Strength of Concrete," by Professor Duff A. Abrams, sums up the results of the most authoritative series of tests on this subject yet published:

> If the evidence of these tests is a satisfactory guide, it appears that there has been a tendency to overestimate the benefiical effects of increased mixing. It is shown that with this mixer the increase in strength which accompanied increases in mixing time from ¾ to 1½ minutes or from 1 to 2 minutes for usual concrete is only about 10 per cent of the 1 minute strength. It seems doubtful if the increased cost of mixing each batch ¾ to 1 minute longer is justified by an increase of 10 per cent in strength. It is the writer's belief that if concrete is mixed 1 full minute after all materials are in the drum, we are getting about the maximum efficiency if the output of the mixer is the factor which controls the amount of work done. Unfortunately, many contractors interpret a 1 minute mix requirement in the specification as meaning 60 seconds if materials happen to be moving slowly, and 10 to 30 seconds when materials are being delivered as intended.
>
> It is folly to insist on a few seconds' increase in mixing time beyond the 1-minute period until more attention has been given to reducing the mixing water within proper limits; especially since we have seen that the wet mixes show decidedly less benefit from continued mixing than the drier ones. A statement made above will bear repetition, namely: No reasonable increase in the making time will compensate for an excess of water in the batch.

The order in which the materials are admitted to the mixer is not material, provided the mixing is adequate after they are all in the drum.

A device to be attached to the mixer to automatically give a warning when the mixing time is completed, or even to automatically dump the batch at the right time is highly desirable. This may be made to depend either upon a definite time interval or upon a certain number of revolutions. Several such devices are upon the market.

Materials must not be introduced into the drum of a mixer while concrete is being discharged.

Consistency of Mix.—In the discussion of proportioning materials for concrete, the following principle was laid down: The amount of water used should be the least that will give a workable mixture. It has been shown that the mixing water is one of the largest single factors upon which the quality of concrete depends.

Water performs two functions in making concrete. (1) It provides for the chemical reactions. (2) It lubricates the mass so that it can be placed.

Only a small amount of water is needed for the chemical action. If more water is used than is absolutely needed for lubrication, a very rapid falling off in strength occurs. How much is needed depends upon the conditions under which the concrete is to be placed. The strength of concrete should increase as the proportion of mixing water is decreased so long as the same degree of compactness is attained. There is a dividing line between mixtures which can be compacted by puddling with a bar and those which require tamping. Mixtures of the second class can only be used to advantage when machine tamping is possible. A slightly plastic mix is preferable to one which must be tamped by hand. In such a case the possible gain due to less water is more than offset by inefficient tamping.

The most advantageous plastic mix is the one containing the least amount of water, which will allow it to be consolidated by puddling with a small bar. Such a consistency is the ideal to have in mind. Of course, conditions, such as presence of reinforcing, thin and intricate sections, transportation difficulties, etc., may render the use of more water necessary, but bear in mind that the consistency to use is the one that will give a workable mixture for the conditions at hand, with the least water.

Consistency is ordinarily tested by observation. The "Slump" test is a convenient and reliable method of establishing and checking consistency and should be used.

Curing Concrete.—Proper curing is important and must never be slighted. Favorable curing conditions are warmth, moisture and protection from extremes of temperature. Concrete will not cure properly if any one of these factors is missing.

Concrete in narrow forms with only a comparatively small surface exposed will ordinarily not need additional water for curing as it will retain the mixing water. Concrete mixed so dry that it requires heavy tamping should be kept drenched with water for several days. Concrete should never be exposed to direct rays of the sun, as this will dry off the surface and prevent proper hardening.

Slabs, walks, and pavements require the most care in curing on account of the large expanse of exposed surface. The only rule needed is to remember to keep them wet for at least 10 days. Protect the surface from the rays of the sun, and do not attempt the job at all in cold weather unless extraordinary methods are used for keeping the concrete warm until it has had a chance to set.

The best method of protection is to completely cover the surface with sand or earth as soon as the concrete has taken its initial set. Then keep this covering wet for at least 10 days.

The surface covering will prevent the premature drying out of the surface. It is just as necessary that there be no drying out from below. Unless the surface upon which concrete is laid is thoroughly wetted it will draw water from the concrete, leaving a stratum of poorly cured material. This is especially liable to happen to walks, pavements, and top dressings placed on old concrete.

The usual specification requiring wetting of the base on which concrete is to be laid is very important and must be rigidly enforced.

In mixing concrete the least amount of water practicable should be used, but in the curing stage the concrete should have as much water as possible.

Removal of Forms.—Forms must be left in place until there will be no damage come upon the structure upon their removal. The necessary time will vary for different types of structures and for different seasons of the year. In concrete bridges the forms should be left in place until the concrete is strong enough to safely carry the full load for which the structure is designed.

Designing loads are ordinarily based upon the 28-day strength of the concrete under normal warm weather curing conditions. The rate of increase in strength of concrete indicates that two weeks is about the safe minimum time for the removal of forms. The centering under concrete spans of 40 ft. or more should be left in place for three weeks or longer. This applies only to warm weather conditions. In cold weather this time should be increased from one week up to several months for concrete frozen during the setting and hardening period. In all cases the inspector must assure himself that the concrete has truly hardened. Experience, judgment and knowledge of the material are needed in forming an opinion.

Building Operations in May Show Decline.—Building operations in the month of May showed a decline of 19 per cent from the operations of the previous month, according to statistics compiled by the F. W. Dodge Co. According to this company's figures, contracts awarded during May in the territory east of the Missouri and north of the Ohio Rivers amounted to $247,186,000, compared with over $300,000,000 for the months of March and April. The principal causes of this slackening of activity are: Disputes over adjustments in the wage scale, principally in Chicago and the Central West; freight congestion, which is felt principally in the East; the increasing difficulty of financing building operations, and the belief that prices of materials are due to drop.

Engineering College vs. Arts College

By P. B. M'DONALD,
Assistant Professor of English, College of Engineering, New York University.

In all institutions that have an engineering college and an arts college, more or less serious disagreement occurs because of conflicting points of view, which have seemed at times to be irreconcilable. The arts college has had somewhat the better of the debate, because of its established position; but in its efforts to culturize the engineering college, there is some doubt whether any result has been accomplished except to delay the progress of engineering education. The engineering college must work out its destiny in its own way; the point of view of the arts educators is so different that, much as they try, they see little of the engineering problems. Extreme as he is, H. G. Wells is partly right in saying that each generation must find its own salvation in its own way. One of the most learned of German scholars has said that if the ancient Greeks, in the midst of their puzzles over philosophy and science, had been given translations of our modern text-books, they would have been no better off, because they had to produce their own explanations.

The point of view of the arts college is that of medieval seclusion from the world. The gifted president of Amherst College has expressed the arts idea in saying that a university should be a place for dreamers—a detached world having no concrete connection with the life around it, and considering everything in the abstract. Since the Thirteenth Century the arts college has persisted successfully in this ideal; if its atmosphere has seemed at times somewhat thin and arid, it nevertheless has built up a tradition that has withstood time and has harbored scholars to whom the world is deeply indebted. Though an occasional protest is made, such as Hardy's novel "Jude the Obscure" (which attacked the insensitiveness and austerity of Oxford), there is no end of good that can be attributed to academic calm and seclusion.

The trouble comes when the engineering college, which is a product of the last several decades, is joined with the arts college and partly controlled by educators of the arts type. The famous Mann report suggested as one of the hampering influences in engineering education the predominance of the arts college in deciding the engineering college's affairs.

Arts professors sniff at engineering professors much as the ancient Greeks sniffed at "barbarians." It is similar to the condescension with which an English lord whose peerage was created in the Thirteen Century looks down upon a baron whose title was awarded very recently and has something to do with trade. Perhaps there is excuse for the sniffing; arts men are cultured scholars in their way while engineers are learned only in practical matters. Yet this is a democratic age, and sniffing is impolite, even in a university. Also, there is something a little ludicrous in the spectacle of arts professors solemnly voting whether graphical statical and geodesy should be included in an engineering curriculum, when there is considerable doubt whether they know what the courses are about. If most engineers are surprisingly ignorant about Plato and Milton and Emerson, most arts men are equally as ignorant about graphical statics and geodesy—and all the rest of engineering.

The really educated man should combine a knowledge of the arts with a knowledge of science and its application. The late Sir William Osler, who was not only a distinguished physician but also a president of the British Classical Association, states the case very well in his recent book on the old humanities and the new science. He advocates no classical studies without science, and no science without classical studies. Perhaps, in half a century or so, educators will begin to take up his recommendations. In the meantime, a few courses in literature and the history of science are being given in engineering colleges, and an occasional arts man picks up a little knowledge about the applications of science. For rest, the battle between arts and engineers goes merrily on, as did the great medieval debate as to whether ideas are realities or names.

Graduates are being turned out of engineering colleges who know less of English history and the classics than a high school boy should know; a writer in the British magazine, Nature, recently expressed surprise that he had talked with a doctor of science who never had heard of Democritus. On the other hand, the war showed examples of men of the traditional arts type put in charge of departments of aviation, submarines, or other applications of science, of which they knew nothing and at which they made lamentable failures costing thousands of lives. An engineer ignorant of literature is no more to be deplored than the post-impressionists of the Lady Clare Vere de Vere type into which some arts graduates develop.

Unfortunately, many of the efforts made to interest engineering students in a broader culture have failed. Probably the fault has lain largely in the teaching; teachers with the right combination of cultural and scientific knowledge are rare. However, men of proper ability usually can be found if sufficient search is made for them. The difficulty has been aggravated by the timidity of most colleges in engaging teachers not of the traditional type. Deans and college presidents have expected to find men of new and unusual qualifications among the conventional instructors with whom they are accustomed to associate. They have looked for imagination and originality where custom reigns; and they have hesitated to permit freedom to instructors who did not seem eminently conventional.

A common argument of the arts is that they are afraid the engineering faculty want to turn the institution into a trade-school or a "cramming factory." Possibly the arts men are too quick to conclude that anything not taught when they were undergraduates is of the nature of a trade-school; they are likely to oppose whatever they do not understand well. In order to win sufficient support to effect improvements, the engineering faculty frequently has to educate the arts in the fundamentals of engineering, or at least teach them what the terms mean. This makes long delays and requires much patience.

However, understanding and cooperation are coming; the most difficult stage in engineering education is past, because a start has been made and the problems are recognized. The arts men are being impressed with the sincerity and soundness of the wish of the engineers to improve their education, and the engineers are awakening to the need for what Sir William Osler called the old humanities. As each faction sees more and more clearly the value in the teachings of the other, readjustment will take place—not very quickly, it is true, for educators have been conservative ever since they had to conform their policies to churchmen and kings and other powers—but it is something to be moving in the right direction!

Drying Periods of Various Woods

Conservative figures to use in estimating the kiln output possible with various woods are given in the following table prepared by the Forest Products Laboratory. Drying time as here given is not limited by the type of kiln, but by the physical behavior of the wood. Any dry kiln in which the circulation is adequate and the temperature and humidity are properly controlled should produce in the time specified material of high quality, free from visible degrade, if not quite equal in strength properties to air seasoned stock.

APPROXIMATE TIME REQUIRED TO KILN DRY, UNDER MILD CONDITIONS, ONE-INCH PLAIN SAWED GREEN AND PARTIALLY AIR DRY STOCK TO MOISTURE CONTENT OF SIX PER CENT, BASED ON WEIGHT OF DRY WOOD.

Species.	—DAYS DRYING TIME—	
	Green from the saw.	Partially air dry (25 per cent moisture content).
Hardwoods.		
Swamp oak	45 to 50	20 to 25
Northern oak	30 to 40	17 to 20
Walnut, cherry	22 to 30	13 to 15
Mahogany, beech	16 to 22	9 to 12
Tupelo, gum	20 to 26	10 to 14
Birch, ash, sycamore	15 to 21	9 to 12
Poplar, basswood, chestnut, butternut, elm, cherry	8 to 10	4 to 6
Maple, hickory	17 to 23	9 to 13
Conifers:		
Western larch	9 to 12	4 to 6
Cypress, redwood	10 to 18	5 to 8
Douglas fir, yellow pine, incense cedar, spruce	4 to 6	3 to 4

For stock over 1 in. and not more than 3 in. thick the drying time is proportional to the thickness. For example, 3-in. stock requires 3 times as long to dry as 1-in. stock. Quarter sawed stock requires from 25 to 35 per cent more time to dry than plain sawed. Drying to 10 or 14 per cent moisture content takes from one-fourth to one-third less time than drying to 6 per cent.

Does Architecture Need a Salesman?*

By EMORY STANFORD HALL.

Does Architecture need a salesman? Yes, architecture needs a salesman, and it is the duty of architects to provide one. Will architects shirk a plain duty to their fellowman? Mr. Sidney Webb, in an address before the Royal Institute of British Architects, among other things, said, "I hope I am not saying anything too hard, but practically the brain-working professions began as the body servants of the rich, and they have not yet sufficiently realized that it is their duty to have developed out of that to beccome the servants of the community; they have not yet managed to make their service available for the whole of the community which needs their service." Mr. Webb's clear, succinct statement referring to the beginning and early practice of the professions is a most apt statement of the case as it applies to the early history of the practice of architecture; but it is likewise true, to a large extent, with reference to present-day practice. Architects have been slow, in common with members of other professions, to come to a full understanding of their duty to the community. This sloth, in the fullest appreciation of community obligation, while operating against the best interests of the community, has also tended to bring this and the other professions into disrepute. No single class of society can long disregard its plain duty to the community without suffering a lack of that public confidence which is so essential to the highest degree of efficiency in service.

Why Architects Have Failed to Get Recognition of Real Merit in Service.—Architects had the confidence and patronage of a considerable clientele which gave them a certain degree of material prosperity; a prosperity which befuddled their reasoning capacity to such an extent as to allow them to come to believe that they were secure in their aloofness from the common need. A false security which they are now beginning to realize through seeing much patronage towards which they had assumed proprietary rights going to others. How have architects acquired these notions, and what has brought about the change, can best be studied by an analysis of the development of Western civilization during the last century.

America has been passing through a more or less chaotic state. Society has not been well balanced, leveling influences have not been fully developed. There has been lack of perspective. These conditions have been fruitful ground for the development of dominant individualism. Enormous individual fortunes have been able to grow in a night. Many have suddenly found themselves possessed of great wealth without the culture essential to its wise use. This lack of culture, on the part of the principal patrons of the professions, has operated against wise choice in the selection of professional assistance. It is not strange that a class which has acquired large wealth without a long, meritorious struggle would be inclined to judge their professional advisers by the same standards that had obtained in their own advance. Men without balancing culture, who had won wealth by sharp tricks or by chance, found no difficulty in convincing themselves that they were made of some superior sort of clay. It was so easy, why any one with brains could be rich, see what I have done; and the converse, any one that is not rich, or does not operate on a large scale, must be lacking in mental capacity.

In face of these conditions the so-called professional man said, "What is the use?" "Bluff" is the word. In the presence of such ignorance, how could the architect be expected to obtain recognition of real merit in service. It was sure to be the architect who could show the largest and highest buildings; the biggest office force; and the richest clients who would be preferred with such a clientele. Technically meritorious performances and equipment did not enter into consideration. The rich man wanted an architect as smart as himself, and to determine this, looked to his, the architects', seeming material prosperity, not to his technical worth.

Now, of course, competent architects know that it requires less dexterity in practice to plan skillfully and supervise the erection of a stereotype skyscraper office building than it does to work out correctly the complicated and much involved details of many a building of very inferior magnitude;

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*From The Architectural Record.

but neither the rich client nor the public understand this, and for that reason, while willing to pay largely for small service on a big project, were unwilling to pay even a living fee for large and very valuable service on small projects.

This attitude on the part of the employing public has tended to divorce the architect from much service where the exercise of his best skill would be of inestimable public value. The factory and the housing problem demand the finest skill of the most diligent and perfectly trained achitects; but since the simplest work pays the largest profit, and complex work of small magnitude pays little or no profit, the latter class of work is not sought by the salesman architect, and cannot be assumed by the professional architect, without serious peril to his economic existence.

It may be observed that in the profession of medicine, the physician is able to make his rich patients pay the bills of the poor, and he is able to live on the average. In architectural practice the salesman architect secures all of the highly profitable business, and leaves the professional architect the complex and difficult middle magnitude work where there can be only a mere living fee with no surplus for the service of the poor. Therefore, the poor get no service, for the salesman architect neither has the disposition nor the ability to render such service, and the professional architect, despite willingness, because of economic limitations, is unable to render gratuitous service. Now the principles of economics make it perfectly clear that no service, no matter how desirable, can be rendered to the public without the public paying a living remuneration to those rendering that service, and since no remuneration for any sort of service can be secured from a democratically governed public, except that public is first convinced of the necessity and value of that service, and since it requires the medium of salesmanship to convince the public, then would it not seem that it is a public duty on the part of the architects to employ a salesman in order that the poor, as well as the rich, many have the gospel of the value of architectural service preached into them.

Architects Must Curry Favor with Collective Small Folk.—Looking at this question from another angle: within the last few years material changes have come about in society structure. Socialistic propaganda is beginning to have its effect; the world war, through which we have just passed, was but an echo of these teachings. We say we have fought to make the world safe for democracy. "Down with the Kaiser," does not mean the elimination of the Prussian royal household or even of the Prussian military system—it means, to a considerable extent, the death of dominant individualism and the pre-eminence of class or vocational socialism, not general socialism.

The people are done with kings either of property or nations, and have found that by organizing themselves, so as to have control of an essential commodity, they can force wealth to its knees. Projects of magnitude will no longer depend for execution upon the will of the rich; but the small man, by joining himself with others, will be able to dictate the success or failure of almost any project.

From a strictly selfish standpoint, therefore, it behooves the architect to curry favor with collective small folk. Now these small folk are too numerous to be cultivated in the same fashion as was so effective with the rich man. Trained in the school of adversity, these folk have learned to judge men on intrinsic worth. They want to know the possibilities of performance. They are being influenced less and less, as the years go by, by the flummery of social prestige and the glamour of tawdry display. What they want to know is what service they can secure that will be of greatest benefit to them.

In place of selecting their professional adviser through personal acquaintanceship, or even directly at all, they will have recourse to the use of some system of collective bargaining. An expert corporate purchasing agent or a collective buyer will be the medium of contract for service, and service will be rated on that person's idea of its economic value. Under these conditions only those who employ the services of the skilled salesman can hope to present adequately the value of professional service.

Since no architect, who can show the highest degree of technical skill in his profession, can possibly be possessed of either time or sufficient skill as a salesman to present adequately his case to the expert purchasing agent representative of a class of collective bargainers, it becomes plainly evident that the architect must, eventually, make use of the expert salesman if they would preserve their identity as a class. For in case they do not make use of such salesman service to convincingly present their claims for consideration they must expect the function which they now perform to fall into the hands of other classes less fitted for that service, but classes which are now making the largest use of expert salesmanship, particularly the great contracting and engineering corporations, which are nothing more nor less than aggregations of brain workers who make use of highly perfected and unusually skilled sales organizations.

With longer training and superior attainment, architects need not fear the competition of the so-called engineering and contracting corporation, provided they are willing to lay aside the dignity and prejudice which has grown out of the necessity of generations of individual patronage on the part of the rich and the powerful, and make use of modern sales methods. There should be no confusion in understanding. In no sense is it advocated that the architect himself should become a salesman. Either he would be a very poor salesman or a very poor architect; and since merit in commodity is essential to the exercise of the best skill in salesmanship, the architect must devote his entire energy to perfecting his technical skill in order that the salesman may have a good case to present.

Advertising the Handmaiden of the Salesman.—Professional codes proscribe advertising in any form as unethical and prejudicial to the best interests of a profession; yet advertising is the handmaiden of the salesman, for commercial experience clearly demonstrates that honest educational advertising is an essential factor in salesmanship. Is it time, then, to do away with established codes, wipe the slate clean, and start over again? Is it expedient for the individual architect to employ advertising in laudation of his individual attainment? It hardly seems so—there were well founded reasons which led originally to the promulgation of the code. These reasons have not been eliminated.

All professional service is personal service, and laudatory reference to it by the producer is equivalent to personal boasting, often rated as exaggerated egoism, and a practice which is always objectionable. Since it is difficult, if not impossible, to escape this objectionable feature in the presentation of the merits of the service of a single individual, it would appear that the only way open to the accomplishment of desired results is for the profession to present its merits to the public by the employment, through its professional societies and associations, of salesmen or organizations who will present the merits of architecture and the necessity of making use of the assistance of expert practitioners.

This method of procedure will, no doubt, necessitate radical changes in architectural practice. Practice will need to be brought up to a uniformly high standard, for if individual merit is to be advocated collectively, then all of the individuals forming the collection must at least have attained minimum standards of qualification for service. The problem of adjusting to new conditions is necessarily complex. It cannot be undertaken hastily; it needs serious thought and constructive criticism.

Conceding that good architecture is essential to the welfare of all, then the public must be made to know what is for their own good and by continuous reminding not allowed to forget. Recent events serve only to prove that it is not sufficient for the public to know its needs, but it must always have those needs forced to its observing attention. Witness the report of the Hughes' Committee on Soldiers' Benefit Insurance, a large percentage of the policies lapsing, not because of lack of funds to pay premiums, nor because of a lack of knowledge as to the value of insurance, but because the men were not continuously followed up and impressed with their duty, as in the case of private insurance where salesmen are paid premiums for keeping policies in force.

These observations force the conclusion that all architects should become members of local and state societies, and either directly or through affiliation with local societies, members and supporters of the American Institute of Architects, and this society should be provided with funds and institute a nation-wide educational campaign for the purpose of acquainting every one with the essential value of architectural service.

How to Check Pier Cribs in Bridge Construction

A useful method of checking the cribs for bridge piers was described by Mr. J. A. L. Waddell, Consulting Engineer, in a paper on "Functions of the Resident Bridge Engineer," in the Journal of the Western Society of Engineers. The following is taken from the paper.

Where bridge piers have to be located by triangulation, it will rarely happen that both of the triangular axes of the pier can be projected over the crib. Frequently, all the lines from triangulation points will make angles with these axes. Before the work of building a crib is started, the Resident Engineer should see that the length of the diagonal of the rectangle thereof is known by his inspectors and that they check frequently the work of building by using it, in order to ensure that the men keep a true rectangle as they add the courses. If the first few courses are properly assembled, there should be very little trouble in keeping the cribs rectangular and the sides true; but if the sides once become warped surfaces, the cribs will tend to run or twist out of position as they go down; and in a high crib the bottom may be far out of the position indicated by the top. Were an 80-ft.-high crib built with a constantly-increasing error in one direction of ⅛ in. in 10 ft., the bottom of the crib would be 8 in. out of position in reference to the top. It is likely that many cribs have been sunk which have been built with much greater warps than that, due to careless inspection during the construction. The smaller the dimensions of a crib the more likely the men are to get a warp in it; and it requires particularly close attention to keep circular concrete shafts true while building them.

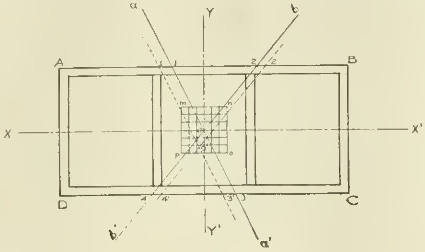


Fig. 1.

When a properly constructed crib is in correct position and truly vertical, the top of any course of timber will be horizontal; and is X X' and Y Y' in Fig. 1 are rectangular coordinate axes which intersect in the center of the crib, and a a', b b' are lines of the triangulation that intersect in the same point O as do the axes X and Y, we could place a platform on the top of the crib and on it mark out at regular intervals lines parallel to the axes of X and Y as indicated by the rectangle m n o p. The amount and direction of any movement of the crib would then be clearly indicated by the position of a mid-point of intersection for the line a a' and b b' as shown in the figure at O', but not coinciding with the intersection of X and Y. The positions of the lines a a' and b b' are fixed, and the dimensions and shape of the crib are maintained as nearly constant as the men can construct it. Hence, if we have a large-scale drawing of the crib, as shown in Fig. 3, on which we have marked the axes X and Y and the lines a a' and b b' in the position they will have when the top of the crib is in true position, and draw the cross-section lines m, n, o, p, etc., to a proper scale, we may find the position of the center of the crib, referred to the intersection of lines a a' and b h', at any time without placing a timber platform over the crib, as follows:

The points where the axes X and Y intersect the crib should be scribed on the outside faces of the timbers, and when the crib is in true position, the triangulation lines will cut the sides thereof in points 1, 2, 3 and 4. We shall assume that an observation has just been made, that the lines were found to intersect at 1', 2', 3' and 4', and that the distances from these points to the axes have been carefully measured along the outside of the crib. Now if we plat three of these points on the edge of our large-scale drawing, then draw two lines on a sheet of tracing cloth intersecting with the same angle as the lines a a' and b b', and then place the tracing cloth over the drawing and shift it until the three lines to be used pass through the three points platted, the two drawings will indicate clearly the amount and direction of any movement of the top of the crib.

The drawing of the crib and the drawing on the tracing cloth should be in ink, and the points platted after each observation should be made in pencil and erased after they have served their purpose. All the measurements made on the crib should be written in the field book at the pier, not brought in on loose scraps of paper to become lost.

Having determined the position of the top of the crib and the elevations of the four corners, the position of the bottom can be calculated by slide rule with sufficient accuracy for most cases. The advantage of this method is that the contractor does not have to stop and place a platform over the center of the crib, and the dredging need not be interrupted more than a few minutes in order to make the observation.

For the first 15 or 20 ft. of sinking the position of the crib should be taken frequently, and it should never be allowed to deviate more than a few inches from the correct position. If the crib is as closely watched as it should be, the amount of deviation of its top from horizontal will be so small that the distances measured along the edges of the timber can be assumed to be of the same length as they would be if taken exactly parallel to similar measurements when the principal axis is truly vertical.

Making Wood Fire Resistant With Paint

Fire retardant paints are the most practical means so far discovered by the Forest Products Laboratory by which small amounts of wood can economically be made fire resistant. The only other known methods of decreasing the inflammability of wood are to keep it wet, or to inject into it certain chemicals under pressure. These methods, though more effective than painting, are usually either impracticable or too expensive to be considered.

Ordinary calcimine or whitewash has proved in tests to be as fire resistant as any paint covering tried. It is cheap and convenient to use. Although it will not prevent the burning of wood exposed continuously to a high heat, a good coat of calcimine on wood will decrease the danger of a blaze spreading from burning cigarettes, sparks, matches, and similar small sources of fire. Calcimine is, of course, more effective for inside than for outside use.

For exterior use numerous patented fire retardent paints are available. An effective outdoor paint which has been developed at the Forest Products Laboratory consists of linseed oil, zinc borate, and chrome green. This paint has maintained its fire resisting properties through more than three years of exposure to the weather.

Salaries in Engineering Colleges.—A letter recently sent out from national headquarters of A. A. E. to 93 deans of engineering colleges, who are acting as corresponding members on the Association's committee on salaries of engineers in teaching service, asks comment on the following positions and salaries:

1. Dean, director or superintendent (reporting directly to the president and responsible as virtual vice-president and operating managers for conduct and policies of engineering department), $8,000 to $15,000.
2. Professor in charge of a department of study (reporting to the dean and responsible for the conduct of his department), $6,000 to $12,000.
3. Professor (a mature man with experience both as a teacher and in the practice of his profession); in full charge of courses of study, $5,000.
4. Special lecturer—By arrangement.
5. Associate professor or junior professor (a younger man, in line for a professorship and in general capable of doing a professor's work), $4,000 to $9,000.
6. Assistant professor (of which there may be two or more grades; may have charge of laboratory, individual course of study, etc.), $3,600 to $7,500.
7. Instructor (teaching sections under general supervision of the professor in charge), $3,000 to $4,000.
8. Assistant instructor (full time), $1,800 to $2,400.
9. Assistant, either class or laboratory (part time), monthly basis.
10. Student assistant, hourly basis.

Field Tests of Reinforced Concrete Beams by U. S. Reclamation Service

Interesting field tests of reinforced concrete beams were made on the Northport unit of the North Platte Project of the U. S. Reclamation Service. While these tests are of little value as furnishing a criterion of probable concrete stresses to be expected with any other gravel than that used in the tests or under different conditions of manufacture, nevertheless the field method of making the tests and the conclusions reached are of considerable interest. The tests are described by Mr. W. H. Fisher, Assistant Engineer, North Platte Project, in the April Reclamation Record, from which the matter following is taken.

The tests were made to determine the advisability of using local gravel found on the tract as a concrete aggregate for canal and lateral features. The nearest good river gravel involves a haul of about 6 to 8 miles, which it was desired to eliminate if possible by using creek gravel found closer at hand. This creek gravel was of somewhat questionable character due to its carrying approximately 20 per cent of its coarser aggregate in the form of sandstone pebbles, which it was thought might be too soft to develop adequate concrete compressive and bond strength. There was little or no question as to the quality of sand which the pit-run material contained as it appeared to be all of good, hard, sharp material.

The available cost data at hand show that with the existing cost of labor, the cost of sand and gravel haul in this vicinity is about 75 ct. per cubic yard-mile. By using the local gravel deposits which are found in the Northport unit, it is estimated that the average length of haul for the work considered would be about 3 miles, as compared with a 7-mile haul if river gravel were used. The total estimated quantity of gravel required on all work considered is in the neighborhood of 8,000 cu. yd., so that the 4 miles of haul eliminated on this quantity of gravel would mean a total saving of about $24,000, a sum well worth considering. The cost of all experimental work done in connection with the beam tests here described was $360, or 1.5 per cent of the saving involved.

In making the tests it was decided not to use any refined or laboratory methods in either the manufacture or testing of beams as it was desired to duplicate field methods ordinarily used in structure work as far as possible, so that a more accurate index of the actual strength of concrete ordinarily used in structures would be available. In all of the beams tested the pit-run material was screened and remixed in proportions of 1:2:4 or 1:2½:5. The cement used was standard tested Portland cement. The pit-run material as found averaged about 50 per cent fine material under one-fourth inch, with the coarser material running from this size up to 1¾ in. average diameter. Some few stones were slightly larger than this, however. Material was screened for sand under ¼ in., but not for the coarser limit, everything above ¼ in. being considered as coarse aggregate.

The Test Beams.—All beams tested had the following outside dimensions: Length 7 ft., width 8 in., depth 4½ in. The effective depth of beams was 3 in., the reinforcing steel being placed with center of bars 1½ in. from bottom of beam. The reinforcing steel for each beam tested consisted of four ½-in. square cold twisted steel bars, spaced uniformly across the plane of effective depth, at 1¾ in. spacing between bars set accurately by means of a templet. The effective depth of beams was purposely made small and the percentage of reinforcing large so that the beams when tested to destruction would all show concrete failures in compression instead of steel failure in tension, so as to secure the desired data as to ultimate concrete strength. The screened sand, gravel, and cement used were all proportioned by dry volume, one sack of cement being considered a cubic foot. The mixing was done in a ⅓-yd. batch mixer such as is ordinarily used on smaller jobs. No attempt was made to gage the water to any fixed percentage basis, the mix being judged by "eye" method alone to secure a medium wet mix. This lack of accurate water measurement would in itself preclude the making of any exact analyses of the results. It is, however, in accordance with ordinary field practice used on smaller jobs where the expense of using more accurate detail methods is usually greater than the net returns from the economies so effected.

The beams were cast in rectangular wooden boxes made of 2-in. lumber, the sides being removable, and each beam during the curing process was left on the plank base on which it was originally cast, to prevent any cracks due to handling. Some of the beams were covered with sand after having been cast; others were not so covered, but were purposely left exposed to weather which at this season was hot and dry. The object was to determine the relative loss of strength due to exposure to the hot, dry atmosphere while the beams were curing. In this connection it must be admitted that this treatment as regards such thin, narrow beams was far more severe than would usually occur in even thin slab work which would usually have much wider dimensions, possibly resting on a ground surface so that the deterioration due to drying out would probably be less than that shown by the beam tests.

In all, 24 beams were tested, 12 each at 30 and 90 days' age. Of each series of 12 beams, 6 were of 1:2:4 mix and 6 of 1:2½:5 mix, and of each series of 6 beams, 3 were covered with sand while curing and 3 were left exposed to weather.

Method of Making the Tests.—All beams were tested to destruction in the following manner: End supports were set 6 ft. apart and consisted of 1½-in. diameter iron pipe resting on a solid timber block which in turn was well bedded in the ground surface. The supports were carefully leveled both longitudinally and transversely. The beam was then placed on the supports with a 6-in. overhang at each end of the beam, leaving a net span of 6 ft. The load was applied at the third points of the span by the use of a wooden platform bearing on two 1½-in. iron pipes. These iron pipes rested directly on top of the beam surface at the third points of the span as above indicated. Each pipe was given a thin sand bearing on the beam surface so as to distribute the load more uniformly and eliminate undue local stresses due to slight irregularities of the beam surface.

The applied load consisted of sacks of cement placed symmetrically on the loading platform. The average weight of a sack of cement proved by tests to be approximately 90 lb. and this weight was assumed to be constant for all loads used. Due care was used to avoid any impact shock on the beam as the load was being applied. The weight of the loading platform as well as the weight of the beam itself were, of course, taken into account in computing the stresses developed. A careful watch was kept for first cracks as the load was applied, but as the nature of the tests was such as to insure a compression failure in all cases the bottom cracks which appeared first were of little interest, merely indicating that the concrete below the reinforcing steel had reached its tensile limit. On the other hand, there were seldom any indications of top cracks until the final ultimate load had been applied, so that as far as these tests were concerned the appearance of first cracks was of little relative importance.

In computing the concrete ultimate strength of beams the parabolic theory of stress deformation for ultimate loads was used as given in Hool and Johnson's Concrete Engineer's Handbook, page 279, and the following assumptions were made as to certain working data used in the formulae:

n = Ratio of moduli, steel to concrete = 15.
A_c = Effective area of concrete = 24 sq. ft.
A_s = Steel cross-sectional area = 1 sq. in.
p = Steel ratio = 1/24 = 0.0417.
k = Ratio of neutral axis depth to effective depth of beam (by formula) = 0.723.
$j = (1 - \frac{3}{8}k) = 0.729$.
b = Beam width = 8 in.
d = Beam depth (effective) = 3 in.

Substituting the above values in the formula referred to, the following relations are obtained:

$M_c = 25.3$, or $F_c = \dfrac{M_c}{25.3}$, and $F_s = 11.53\ F_c$, which are applicable, of course, only to ultimate load conditions.

Results of Tests.—All beams tested failed either under one, or between the two one-third points of the span, so that the bending moment due to all external loads was equal to 12W (inch-pounds) where W is the total external load. The bending moment due to the weight of the beam itself would theoretically vary between the third points of the span by not more than 1 per cent of the total ultimate bending moment resisted. This variation was neglected in all cases, and the bending moment due to the weight of the beam assumed as constant and equal to that occurring at the center of the span; that is, equal to 1,980 in. lb., which is additive to the external load-bending moment above described.

The tabulated results of beam tests show all the essential factors involved, and the computed steel and concrete stresses at ultimate load, also a column giving the nominal factor of safety that would obtain under given conditions. This nominal factor of safety has been obtained by dividing the total load at which failure occurred by that nominal load for which the beams would ordinarily have been designed, using the straight-line formula of stress deformation and with assumed unit working stresses of 520 lb. per square inch for 1:2½:5 concrete, and 650 lb. per square inch for the 1:2:4 concrete. These unit working stresses correspond to those recommended for a good gravel concrete at 28 days of age, by the Special Committee on Concrete and Reinforced Concrete of the American Society of Civil Engineers.

On nearly all these tests, the failure was in the mortar or mortar bond on gravel except in those tests showing an ultimate stress near 2,000 lb. per square inch where a few of the sandstone pebbles before mentioned were sheared. This shows that as far as quality of coarse aggregate is concerned, suitable concrete would be made from this gravel for any and all required structures. All beams that failed at the lower unit concrete stresses, judging from indications at the point of fracture, seemed to carry a larger percentage of the coarsest aggregate than those which failed at the higher unit stresses. This was to be expected, since on such thin slabs the finer aggregate would naturally develop higher strengths than the coarser aggregate. On all beams that were left exposed to weather while curing there was evidence of the concrete having dried out too rapidly, as shown by the greater percentage of mortar bond failure on gravel in those beams.

There was no evidence in any of the tests that failure had occurred by failure in shear or diagonal tension. All the failures were evidently due to crushing of concrete near the top center of beam, and there was no evidence of cracks extending along the plane of reinforcing steel to either side of the point of failure. As the effective depth of the beams was very small compared with the net span, there was relatively a much smaller chance of failure due to diagonal tension or shear than if the relative effective depth of the beams had been greater.

Conclusions from the Tests.—In all cases a marked increase of strength was shown by those beams covered with sand while curing as compared with beams of the same age and mix that were left exposed to the weather. This is, of course, to be expected and is generally well known. The increase of strength due to covering beams, while curing, by the above tests varied from 40 per cent to 55 per cent.

TABLE I—CONCRETE BEAM TESTS, NORTHPORT UNIT, NORH PLATTE PROJECT.

Beam test No.	Concrete mix—ratio.	Beam age.	Treatment of beam while curing.	Ultimate strength test data.—Total external load.	Ultimate bending moment.	Computed steel stress per sq. in.	Computed concrete stress per sq. in.	Nominal factor of safety.
		Days.		Lbs.	In.-lbs.	Lbs.	Lbs.	
1	1:2½:5	30	Exposed	1,810	23,700	10,800	937	2.3
2	1:2½:5	30	Exposed	2,170	28,020	12,780	1,108	2.7
3	1:2½:5	30	Exposed	1,360	18,300	8,340	723	1.7
4	1:2½:5	30	Covered	2,530	32,340	14,750	1,279	3.2
5	1:2½:5	30	Covered	2,600	23,180	15,220	1,320	3.3
6	1:2½:5	30	Covered	2,500	31,980	14,590	1,263	3.2
7	1:2½:5	90	Exposed	2,250	28,980	13,220	1,145	2.8
8	1:2½:5	90	Exposed	2,610	33,300	15,200	1,317	3.3
9	1:2½:5	90	Exposed	2,350	29,940	13,670	1,183	2.9
10	1:2½:5	90	Covered	3,420	43,020	19,630	1,702	4.3
11	1:2½:5	90	Covered	3,850	48,180	22,000	1,905	4.9
12	1:2½:5	90	Covered	3,240	40,860	18,630	1,614	4.1
13	1:2:4	30	Exposed	2,260	29,100	13,280	1,150	2.3
14	1:2:4	30	Exposed	2,170	28,020	12,780	1,108	2.2
15	1:2:4	30	Exposed	1,990	25,860	11,800	1,022	2.0
16	1:2:4	30	Covered	3,060	38,700	17,650	1,530	3.1
17	1:2:4	30	Covered	4,060	50,700	23,120	2,030	4.1
18	1:2:4	30	Covered	3,090	39,060	17,820	1,544	3.1
19	1:2:4	90	Exposed	2,250	28,980	13,220	1,145	2.3
20	1:2:4	90	Exposed	3,250	40,980	18,700	1,620	3.3
21	1:2:4	90	Exposed	3,240	40,860	18,620	1,614	3.3
22	1:2:4	90	Covered	4,060	50,700	23,150	2,005	4.1
23	1:2:4	90	Covered	4,670	58,020	26,480	2,295	4.7
24	1:2:4	90	Covered	3,850	48,180	21,980	1,905	3.9
AVERAGES ON ABOVE RESULTS.								
1- 3	1:2½:5	30	Exposed	1,780	23,340	10,650	923	2.2
4- 6	1:2½:5	30	Covered	2,543	32,500	14,850	1,285	3.2
7- 9	1:2½:5	90	Exposed	2,397	30,780	14,050	1,215	3.0
10-12	1:2½:5	90	Covered	3,503	44,020	20,100	1,741	4.4
13-15	1:2:4	30	Exposed	2,140	27,660	12,620	1,093	2.2
16-18	1:2:4	30	Covered	3,403	42,820	19,520	1,700	3.4
19-21	1:2:4	90	Exposed	2,913	36,940	16,850	1,460	2.9
22-24	1:2:4	90	Covered	4,190	52,300	23,850	2,068	4.2

The 1:2½:5 beams covered while curing, for both 30 and 90-day tests, were stronger than the 1:2:4 beams of the same age that were not covered while curing.

While concrete dries out too quickly after being placed, there is a marked decrease of strength shown, due largely to failure of mortar bond on the coarser aggregate.

Considering the rough field methods used in making these tests, taken as a whole they give rather logical results, and fully answer the requirements for which the tests were made.

Overheating Reduces Strength of Animal Glue

That long continued heating reduces the strength of animal glue solutions is demonstrated by the following test made at the Forest Products Laboratory:

Solutions of a high grade joint glue and a veneer grade glue were heated for 48 hours at 104°, 140° and 176° F., and tested every few hours during this period for strength and viscosity.

In the first seven hours of heating at 176° the veneer glue lost approximately one-half its joint strength, and the high grade glue joints weakened almost as much. The greatest loss in the strength of the glue joints occurred at this temperature. In the solutions kept at 104° there was a sudden drop in the strength of the joints made with the high grade glue after 31 hours of heating, due possibly to a combination of bacterial and chemical action. The veneer glue joints showed a more gradual decrease at this temperature. The most favorable of the three temperatures tried was 140°, but even at this temperature an appreciable weakening in both glues was noted at the end of seven hours, and longer heating caused greater loss.

The viscosity of the high grade glue declined more rapidly than that of the veneer glue, but at the end of the heating test the viscosity of the high grade glue still averaged higher than that of the veneer glue.

Covered glue pots were used in this experiment. When open glue pots are used the loss in strength caused by the heat is less apparent, since the loss is compensated to some extent by evaporation of the water. On the other hand, the concentration of the glue solution through evaporation is an expensive means of gaining strength.

Comparative Value of Timber Cut From Live and Dead Trees

Prejudice exists in certain quarters against the use of timber cut from dead trees, and some purchase specifications insist that only timber cut from live trees will be acceptable. As a matter of fact, when sound dead trees are sawed into lumber, and the weathered or charred outside is cut away, there is no method known to the Forest Products Laboratory by which the lumber can be distinguished from that cut from live trees, except that the lumber from dead trees may be partly seasoned when sawed.

All the information available at the laboratory indicates that timber cut from insect or fire-killed trees is just as good for any structural purpose as that cut from live trees of similar quality, providing the wood has not been subsequently injured by decay or further insect attack. If a tree stands on the stump too long after it is killed, the sapwood is likely to become decayed or badly infested by wood-boring insects, and in time the heart-wood also will be similarly affected. The same thing is true of logs cut from live trees and not properly cared for. Until the wood becomes affected by these destructive agents, dead tree wood should be just as strong and just as durable as sound live tree wood.

In considering the subject it may be useful to remember that the heartwood of a living tree is entirely dead, and in the sapwood only a comparatively few cells are living. Most of the wood cut from trees is dead, therefore, regardless of whether the tree itself is living or not. Such being the case, purchase specifications, instead of providing that material must not be from dead trees, should state that material showing evidence of decay or insect infestation exceeding a specified limit will not be accepted.

Method and Cost of Installing Drainage System to Prevent Settlement of Factory Foundations

Foundation troubles that threatened to ruin an $800,000 industrial plant were remedied by the installation of a system of under drainage at a cost of less than $20,000. The factory buildings covering about 2 acres were erected during 1917 on a bench of land adjoining the east bank of the Mississippi River, 75 ft. below the top of a bluff and 150 ft. above the river. The owner was not represented on the work by an engineer or building inspector. The work was carried out by an engineering contractor on a cost-plus-fee contract. Following the completion of the plant, settlement occurred in the foundations under practically all the buildings and machinery, and it appeared that the entire building site would slip down the hill. Investigation disclosed that the trouble was due to softening of the top 20 ft. of soil by water that could not escape through impervious blue clay under it.

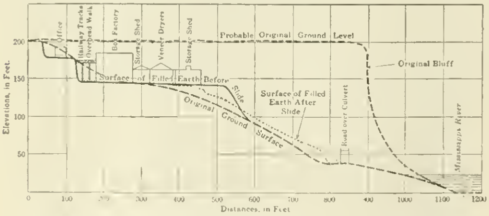
The following particulars regarding the installation of the drainage system and its cost are abstracted from a paper by Mr. C. E. Smith in the May Proceedings of the American Society of Civil Engineers:

A comprehensive system of porous under-drains, with a combined length of 2,870 ft., was placed under and around the principal buildings of the plant. These drains consisted of tile pipes or perforated wood boxes placed at depths of from 10 to 25 ft. in trenches, which were then back-filled with gravel or cinders. The trenches averaged 30 in. in width, which was as narrow as they could be dug conveniently to the required depth.

Tile pipe of sizes from 6 to 12 in., which could be placed more cheaply than wood box, was used in all lines where the earth was not moving; but at points where movement was taking place it was found that sections of pipe pulled apart too easily, and continuous wood box was used instead. Wherever possible this was kept below the plane of the slide.

This wood box was built of 2 by 12-in. cypress planks, the sides resting on the bottoms so as to make the interior dimensions 8 in. wide by 12 in. high. The sides and top were perforated with 1-in. holes in two rows, at 8-in. intervals in each row. The joints between the side and bottom planks of the box were well caulked with oakum and then covered with narrow lath. These joints were broken so as not to have successive planks in the side to join at the same section at which planks joined in the top and bottom; all were held by 2 by 12-in. scabs, 3 or 4 ft. long, well spiked at both ends so as to keep the box from pulling apart during slight movements of the earth. The lumber used was a low grade of pecky cypress which was found to be quite satisfactory.

From the lower ends of the under-drains the flow was carried down the hillside in open flumes of wood, of the same cross-section as the box underground. Points at which the drains came to the surface were selected, on steep slopes, so as to have the drain-pipe or box pass through as short lengths as possible of the surface earth, as this was constantly in motion and tended to pull the sections of pipe and box apart. The open flumes were placed on timber bents spaced 10 or 12 ft. apart. The flume was kept from disjointing at each slight displacement of the bents due to movement of the earth. The bents could be put back in place after each movement without injuring the flume.

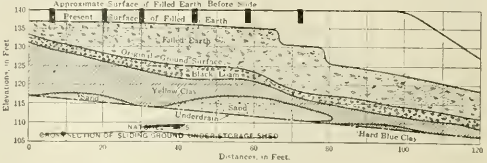


Cross Section of Factory Site From Bluff to Mississippi River.

After the completion of the under-drains the earth near them, especially on the hill sides, was graded to slope uniformly toward the gravel-filled trenches through which the water passed to the under-drains.

The flow through the several drains was measured daily during their construction, and that through each drain was found to decrease gradually for two or three weeks after its completion, which indicated that the level of the groundwater was being slowly lowered. The total underground seepage after the drains had been in place sufficiently long to have reached their minimum of flow, and after defects in the surface drainage had been corrected, amounted in the driest weather to about 12,000 gal. per day from an area of about 4 acres, 2 acres of which are covered by buildings the drainage from which is otherwise disposed of. This was increased to about 100,000 gal. per day in very wet weather.

Movement of the ground stopped promptly at one point after another as the drains at these respective points were completed, until the work was finished. After completion, not the least movement could be noticed at any time. The earth, which formerly was muddy and soggy from one rain until the next, now dries rapidly after each successive downpour and is perfectly stable.



Cross Section of Sliding Ground.

The drains were placed during the early summer of 1919. In February, 1920, the manager of the factory advised "that even in the face of the continuous rains all through the summer and up to the present time, even in a heavy rain which we had in January, when it rained about 7 in. in two days, that there was absolutely no movement in any part of the hill where the drains were put in."

The cost of the work was as follows:

Excavation per Cubic Yard:	
Handling earth (in addition to actual excavation, this includes an average haul of 250 ft. for all excavated material)	$2.00
Miscellaneous items (this includes bracing the trench, foreman's supervision, trench-jacks, lumber and rubber boots)	1.35
Total	$3.35
Back-filling per Cubic Yard:	
Labor (this includes handling of gravel from railway cars to the several drains, with an average haul of 250 ft.)	$1.90
Gravel, including freight	2.10
Total	$4.00
Placing Wood Box per Linear Foot:	
Labor (time of carpenters and laborers building the box and placing it in the trench)	$0.65
Cost of timber	.20
Total	$0.85
Placing Tile Pipe per Linear Foot:	
Labor (time of foreman and laborers carrying the pipe from stock piles to the drains, and placing it in position)	$0.20
Tile pipes, including freight	.35
Total	$0.55
Cost per linear foot on all operations	7.20

The trenches reached a maximum depth of 25 ft., with an average depth of 15 ft. All trenches were braced. In many places the soil ran through the cracks like soft ice cream.

The unit costs for material and labor were as follows:

Cost of Labor per Hour:	
Foreman	$ 0.75
Carpenter	0.50
Negro laborers (10-hour day)	.25 to .30
Costs of Materials per Cubic Yard:	
Gravel ($1.20, freight $0.90)	$ 2.10
Cinders (loading and switching charges only)	.80
Lumber, pecky cypress, per 1,000 ft. b. m.	30.00

Tile Pipe:

Size, in in.	Pipe.	Freight.	Total.
6	$0.19	$0.05	$0.24
8	.27	.07	.34
10	.37	.09	.46
12	.58	.12	.70

Bridge Engineers for Government Service.—The U. S. Civil Service Commission will hold open competitive examinations to secure highway bridge engineers and junior highway bridge engineers to fill vacancies in the Bureau of Public Roads. Salaries of the first mentioned range from $2,100 to $2,700 a year—of the junior engineers, $1,320 to $1,920. Applications must be filed with the Civil Service Commission, Washington, D. C., before July 13.

Report of American Concrete Institute Committee on Fire Proofing

As the result of additional fire tests of concrete columns at the Pittsburgh laboratories of the U. S. Bureau of Standards, the Committee on Fire Proofing of the American Concrete Institute in its report, submitted at the 1920 convention of the Institute, makes several changes in the recommendations in its 1919 report.

As was noted in the previous reports of the fire tests of concrete columns made at Pittsburgh, extensive spalling has invariably taken place in the fire tests of hooped columns from highly siliceous gravels, made in the usual way. Most of the columns tested have had a thickness of 1½ in. of protective concrete over the steel. In the recent tests two columns, Nos. 79 and 80, from Pittsburgh gravel with 2½ in. of protective concrete (see table) gave results that were distinctly better than those with protective concrete only 1½ in. thick (Nos. 73, 74 and others), and yet so poor, in comparison to those shown by columns from more favorable aggregates, with 1½ in. of protective concrete, that the expedient of securing better protection in the case of columns from highly siliceous gravel, by providing an unusual thickness of protective concrete, does not seem worthy of recommendation.

DATA FROM TESTS OF ROUND HOOPED COLUMNS OF 15. IN. EFFECTIVE DIAMETER.

Aggregate.	Column No.	Thickness of protective concrete, in.	Time of failure under working load. Hrs.	Min.	Max. stress tested cold without fire test. lbs. per sq. in.	Max. stress at end of 4 hr. fire test lbs. per sq. in.	Max. stress tested cold having been loaded to 3,480 lb. per sq. in. at end of 4 hr. fire test.
	73	1½	3	50	.....	.....	.....
	74	1½	3	20	.....	.....	.....
	75	1½	..	.	4.880	.....	.....
Pittsburgh gravel............................	*77	1½	..		.....	1,995	.....
Pittsburgh sand..............................	*78	1½			.....	2.120	.....
	79	2½	.	..	.....	1,495	.....
	80	2½	..		.....	1,640	.....
	81	2½	..	.	5.590	.....	.....
	*82	2½	..	.	.....	....	5,115
	*83	2½	..		.....	.....	4,950
	*84	2½	.	..	5.155	.....	.....
High limestone gravel.......................	85	1½	.	..	....	.....	4,440
High limestone sand.........................	86	1½	..	..	.....	.....	5,240
	87	1½	..	..	5,620	.....	.....

*Columns which had expanded metal in the protective concrete.

On the other hand, the two columns from Pittsburgh gravel, Nos. 77 and 78, with a thickness of 1½ in. of protective concrete, reinforced by a light grade of expanded metal, of large mesh, to prevent the loss of protective concrete by spalling, gave fairly satisfactory results. While the results of the test of these columns were not as good as those from columns from limestone, trap rock and blast furnace slag aggregates, the loss of strength in the 4-hour fire test, as determined by loading to failure in the furnace while the column was still hot, was less than 60 per cent in both cases, which presents a strong contrast to the results from columns from the same aggregate, Pittsburgh gravel, without reinforcement in the protective concrete, which failed under the working load before the 4-hour fire test was completed.

Columns from Pittsburgh gravel, Nos. 82 and 83, with 2½ in. of protective concrete, with the light, expanded metal reinforcement in the outer concrete, to prevent the loss of protective concrete by spalling, could not be loaded to failure in the furnace, at the end of the 4-hour fire test, due to the fact that their strength exceeded the load limit of the furnace equipment, which is equivalent to a stress of approximately 3,480 lb. per square inch on the effective area of these columns. When tested cold, after fire test, in a testing machine of high capacity, these columns showed an ultimate strength only slightly lower than that of a similar column, No. 84, which had not been subjected to fire test.

Judging from these results, it would appear that if the protective concrete of columns from highly siliceous gravel aggregates were reinforced with expanded metal so as to prevent loss of protective concrete by spalling, they would be sufficiently protected by the thicknesses of protective concrete recommended for different conditions in the last report of this committee. The expedient of providing such reinforcement in the protective concrete of columns made from highly siliceous gravels is accordingly included among the recommendations for columns.

Two gravel concrete columns, Nos. 85 and 86, in which the aggregate was low in quartz content, have been fire-tested. Approximately 90 per cent of the gravel was made up of limestone pebbles, and there was a high percentage of limestone in the sand. The columns had 1½ in. of protective concrete with no expanded metal. These columns showed no tendency to spall in the fire test and gave comparatively good results in other respects. Neither of them failed under the maximum furnace load when tested hot at the end of the four-hour fire test. When tested cold, after the fire test, the ultimate strength was found, in both cases, to be more than 75 per cent of that of a similar column, No. 87, which had not been submitted to fire test.

These results indicate that gravels and sands that are very high in limestone content are suitable for use in fire-resistive concrete. It is probable that all gravels that are low in quartz may prove, on investigation, to be free from the spalling tendency. How high a proportion of quartz can be included in gravels without the resulting concretes spalling under fire test conditions cannot be determined from the tests thus far made. The evidence now available appears to be sufficient, however, to justify the recommendation, which is to be found in a later paragraph of this report, that gravels high in limestone content be given a preference for fire-resistive concrete, over highly silicious gravels.

The recommendations made in the report of the committee, for 1919, amended to conform to the evidence presented in the foregoing discussion, may be stated as follows:

1. That in concrete columns where four-hour protection is required, protective material not less than 2 in. in thickness shall be provided over the steel. In columns in which a high percentage of steel is used, increasing the importance of affording it ample protection, the thickness of protective material shall be 2½ in. for four-hour protection, and special care shall be given to the accurate placing of the steel in the forms, to avoid inadequate protection on any side.

2. That for fire-resistive construction, limestone, trap rock, blast furnace slag, well-burned clay and gravels, composed largely of limestone pebbles, be given a preference over highly silicious gravels.

3. That where highly silicious gravel aggregate is to be used in columns without hooping, and with no special safeguards, round columns be given a preference over rectangular ones.

4. That where highly silicious gravel aggregate is to be used, all columns, but especially rectangular columns and round columns with spiral reinforcement, be safeguarded by means of the following expedients:

(a) Placing expanded metal or other high-weight large-mesh reinforcement in the outer concrete to prevent the loss of protective concrete by spalling.

(b) Giving columns additional protection of approximately 1 in. of cement plaster either on metal lath or reinforced with light expanded metal or other suitable material.

Building Data to Be Submitted to Senate Committee.—The presidents and secretaries of the fifty odd associations affiliated with the National Federation of Construction Industries, met at the Union League Club, Philadelphia, last week, to arrange for the preparation of statements to be submitted to the U. S. Senate Special Committee on Reconstruction and Production, which has recently been appointed and is particularly charged with the fostering and stimulating of construction work of all kinds.

onomy in School House Planning and Construction*

By W. R. McCORMACK,
Architect, Board of Education, Cleveland, O.

A prominent state official recently made public a statement that millions of dollars are being wasted in the state of Ohio in costly facades to school buildings. Unfortunately, this reflects an erroneous but often popular opinion, the facts being that in the most ornate public school buildings all the stone work, including base courses, steps, window sills, belt courses, copings and ornamental work does not exceed 4 per cent of the total cost of the building and the ornamental stone work not more than 1 per cent. For the aesthetic welfare of any community this small expenditure can and should be defended.

Inadequate Architectural Service Cause of Wasteful Planning. It is not elaborate facades but wasteful planning that costs money. What are the causes of this waste?

The greatest cause is inadequate architectural service, which must inevitably result in wasteful plans and inferior buildings.

It is a fact that there is a greater percentage of poorly designed and poorly built schools in this country than any other type of building, except some of the very cheapest commercial forms. It is also a fact that only a very small percentage of the architects who have attained a commanding position in the profession due to careful training and experience, plan and build schools.

Why is this true?

It is true too often because school authorities listen to architects who present their cases on the basis of cheap commissions, and because they claim they can build school buildings for less money than their competitors, and also because the architect and educator fail to co-operate.

When the knowledge becomes common that a school is to be erected in a community not only are well qualified architects considered but less qualified of the profession present their cases, the latter agreeing to do the work for 3 or 4 per cent, when it is a well known fact that no architect can provide thorough study and good service for any such price, yet many of the school authorities will be taken in by this argument.

You buy clothing or any other material and expect to pay the merchant 15 per cent or 20 per cent or 25 per cent profit Without question you allow the contractor 10 per cent or 15 per cent profit with his overhead, but the architect is supposed to provide more service and assume more responsibility than the contractor, and the architect's smaller fee must include his overhead and what profit he can make.

Not until we appreciate architectural service on a higher plane with higher fees and make the architect financially responsible for all the errors in the plans, will school authorities secure service which means the elimination of waste in schools, better buildings, which means less maintenance cost in the future, and structures of such architectural quality that they will be an asset to the community.

Saving Space by Standardizing Equipment.—In the Cleveland school system for years a certain desk was standardized. This desk required a room 25 ft. wide and 32 ft. long to seat 42 desks of a given size. Be redesigning the furniture, it was found possible to place the same number of desks in a room 24 ft. wide and 28 ft. long, thus bringing about a saving of 3,000 cu. ft. per room, which at a per cubic foot cost of 20 ct. means a saving of $600 per room or more than double the cost of the furniture. In a 30-room building this means a saving of $18,000. This amount at compound interest for 50 years, or the life of a building, amounts to $20,000 per room or $600,000 for a 30-room building—enough to pay for the building.

What seems to be very minor matters in planning are full of danger and financial calamity to groups of school authorities continuing to pursue a policy of careless planning, and indicts any architect or school man continuing to disregard the study of the problem of saving space. On the other hand, this reduction in class room area does not show to advantage when comparing class room areas with corridor areas, and we must be alive to these facts in our studies of standardization and comparative areas.

Space Wasted by Stairways and Corridors.—But there is a much more serious problem in the matter of waste space which has gone unchallenged for decades. It has caused such an alarming waste of money in this country that remedies must be found without further delay before millions of dollars more are thrown away.

This has to do with waste due to stairs, and corridors. There are 1,250,000 sq. ft. of floor space in the school buildings of Cleveland devoted to stairs and corridors. This is an area equivalent to 1,560 class rooms or enough to accommodate 62,400 children, and at the present cost of building in the city of Cleveland it would require $35,000,000 to construct this number of rooms.

Considering that Cleveland is equal to one one-hundredth-and-twentieth of the population of the country, the space devoted to stairs and corridors in the entire country is equal to 187,200 class rooms, or a seating capacity for 1,480,000 children, and the replacement cost would be $3,744,000,000.

We must, however, admit that a certain amount of unuseable space is necessary in any type of building.

Cleveland has been studying the question of elimination of waste space, with the result that three types of plans have been developed. These types are:

One-story corridorless elementary school—10 per cent of the floor area in corridors.

Three-story corridorless elementary school—12 per cent of the floor area in stars and corridors.

Junior high school combination 1 and 3-story building—15 per cent of the floor area in stairs and corridors.

Assuming that 15 per cent is the average amount of waste space in these new types of plans, there is a difference of 10 per cent between the average waste space in the Cleveland school today and the waste space in the proposed new types.

Forty per cent of the 1,250,000 sq. ft. of stairs and corridors in the buildings of the present Cleveland schools has been crimanally wasted. This is equivalent to 625 class rooms, representing seating accommodations for 25,000 children, and these 625 class rooms at the present cost of construction in Cleveland would require $15,000,000 to replace. Using the ratio of population of Cleveland to that of the nation mentioned above, the unnecessary waste in the entire country amounts to 75,000 class rooms or seating space for 3,000,000 children, and the replacement cost is $1,500,000,000.

For the sake of making the comparison fairer on account of lower building costs in some sections and possibly less waste in others, let us arbitrarily reduce the waste by 33⅓ per cent, with the result that space equivalent to a seating capacity for 2,000,000 children at a replacement value of $1,000,000,000 has been wasted in the schools, in this country, while cheaper school buildings have been made necessary, while the children have been denied the refinements in equipment which they should have and the community buildings of the highest architectural and structural standards. Such architecture produces structures whose cheapness results in a tremendous overhead cost of maintenance, and these results have been brought about by architects who have not thought of buildings as having a financial return on the investment.

This deplorable situation exists because a school building has never shown nor is it probably possible to have it show a financial return on the investment.

Hotels and office buildings require a large amount of stairs, corridors and lobbies, because of the small units, each of which must be reached independently; yet no hotel or office building properly planned shows more than 15 per cent waste space, and mercantile establishments and factories almost nothing. No architect could survive who planned buildings of this type which require a definite financial return on the investment who would plan a building with the excessive amount of waste space existing in our schools, in addition add to the corridor and stair waste, all the basements, oversized rooms, schools used during a small portion of the year, and we have a condition of waste of school funds so stupendous as to be almost beyond belief.

It is time for all school architects and school men to stop and at once inaugurate a policy of intensive study of the school building problem; to reduce its cost without injuring its beauty and its usefulness or construction value, and I believe this study should be concerted and nation wide, and that a national bureau for such study is not too visionary a proposal to be idly passed by.

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*Abstract of a paper presented Feb. 26 at the convention of the National Education Association

Public Information on Technical Matters*

By D. KNICKERBACKER BOYD,

The difference between publicity and public information we must first establish clearly in our own minds. You are all familiar with the fact that organizations have committees on publicity, conventions have committees on publicity, and that cities have committees on publicity, but in that sense publicity is what we might term advertising in advance something which may never happen.

The Meaning of Public Information.—Now, public information, as I see it, is that which follows the event. We who are doers and actors on the stage of public service, and all others who are engaged in the performance of duty, first do that thing If we do it well we make news, and when we make news it is published and is spoken of by word of mouth, and then it becomes public information. That is the difference, as I see it, between publicity and public information.

When talking about public service and architects, engineers and other servants of the public, the question is, who are they? what are they? what do they do? and it is here that the functioning of committees on public information in the engineering organizations, in architectural organizations, and in all other professional and efficient organizations comes in. For lack of just such information I would not be surprised if the man in the street has not the faintest idea of what an engineer is, just as he thinks that the architect can be easily dispensed with. Probably it is thought that an engineer must be one who drives either a stationary engine or a locomotive.

More should be known about the kind of service which. as public servants, engineers and architects render. If such were the case, do you suppose that we would need a discussion as to whether the Delaware River bridge or any other bridge should be designed and supervised and controlled by an architect or an engineer? No. Anybody with common sense would see that the only way to have a successful termination of an important project like that, with all its features of planning and approaches, would be to have both an architect and an engineer—a combination.

How Committees on Public Information Could Serve.—These committees on public information are very necessary in many ways. They stimulate the activities of all other committees in an organization. They bring about co-ordination of activities. They not only make new activities in the other committees, but they record them. We are accustomed to think that these activities are fine, because we read in the Engineers' Club Journal or the Journal of the American Institute of Architects about the doings of our respective organizations. They are on the job, doing great work. But these activities are published in a magazine which we ourselves see, but very few outside of our immediate circle, and our circle is a continuous circle, like the dog chasing his tail, who thinks he is getting along, but nobody knows it outside. The fact is, that these are published in our own magazines, but it is only the beginning. From that point it should be taken up by a Committee on Public Information which should read, digest, and transmit to all factors in the United States or in all localities the principal features of interest contained in those actions by the various organizations. I just want to give you one concrete illustration. At the convention of the American Institute of Architects last May a year ago at Nashville, Tenn., a resolution was adopted which read:

> That securing gratuitous expert service from contractors or material men in connection with the preparation of plans and specifications is contrary to the spirit of the Circular of Advice; is contrary to the best interests of the owner, belittles the profession in the eyes of the building world, and can not be too strongly condemned. Every individual architect should not only refrain from such practice, but take every opportunity to discourage the practice by others.

In September, 1919, I had not heard of that resolution being published anywhere in the United States or heard it commented on. So I thought, as the resolution concerned principally the heating and ventilating contractors, I would write and find what they thought of this resolution. I wrote to the American Society of Heating and Ventilating Engineers, the Piping Contractors' Association, the Heating Contractors' Association, and the Warm Air Contractors' Association. I also wrote to several individuals and asked them what they thought of this resolution, but no one of them had ever heard of it. I wrote to the secretary of the American Institute of Architects, and he said: "It was first printed in the journal, then sent to the institute membership as part of the proceedings; then distributed to some 5,000 non-institute architects as well as a great many members of the institute in the post-war document, and through its publication in the journal it has gone to the regular list of organizations and magazines that are on the regular list of exchanges with the journal." But it was just like one of the many gems in that publication. You put it on the table of the man that it was sent to; he hopes to dive into it and get out what he wants. He will never do it, and it was never done, and up to the first of the year nothing was said about it.

After the matter was drawn to their attention to me, who happened to be an individual in the institute, they all came out in their publications and gave it a wider circulation by tens of thousands than ever before, each one in its own circle. That is one way that we could do. It is as if we should say it was not necessary to have ministers, because the Bible was full of the wisest words ever written. It is just as if we should say we should never have actors portraying Shakespeare on the stage, because the books are on our shelves in all the libraries of the country, and in all the homes of the civilized world. We need some one to transmit the message, and it should be in the form of public information.

Why Governmental Bulletins Do Not Serve Their Full Purpose.—Take the Government, for instance. There are various departments that publish bulletins of informative value to technical men, and many of them of value to the public at large. Who hears about them? They are published at the expense of you and me and everybody else as public documents, and the announcement is merely made here and there and sometimes not at all that the scientific research, the investigations that have occupied months and years of capable men, are published in the document, and there it lies dead, and yet for nothing, in most cases, or for 10 or 15 ct. it can be purchased from the Government Printing Office. But who knows about it?

I had a talk with George Otis Smith, one of the many public service officials, and he said: "Mr. Boyd, what you are saying is perfectly true. The United States Government needs what might be called a press agent." The United States Bureau of Standards, for instance, issues a book that ought to be in the household of every owner or every occupier of a residence in this country. It is called "Safety in the Household"; but do you know of any householder who knows about this book? It is highly valuable. It tells, for example, how to save lives in case of emergency in choking. I know that many a death could have been prevented and a life saved if that book had been in the household. That is but one illustration.

Opportunities for National Public Information Committees.—The Department of Agriculture issues bulletins which, fortunately, are known to the farmers. If there is one association which is unorganized it is the farming—the agricultural interests of this country, and what success they have may most largely be attributed to the Agricultural Department of the United States Government.

They also have a forestry service which is mainly intent upon saving the forests of this country, saving the lumber and conserving the watershed. I claim today that we ought not to use in building construction any piece of timber for the walls of a building or the cover of a roof where any product extracted from the earth can take its place. We have all the uses that can possibly be put to wood in the interior and other furnishings which cannot be met so well as by wood.

The Navy Department has courses of engineering all over the country. Some of you may know about it, but few architects know about the specifications which can be had merely for the asking, and with regard to all kinds of materials.

The same way with the National Bureau of Education. It issues models on public schools, bulletins on fire prevention in schools, and bulletins on vocational studies, but the message does not get across to the people on the outside that this work is being done, except here and there, as, for instance, in the case of the National Association of Education, a meeting of which I attended last month where there were 9,000 people present. They were teachers of the professional class, but they were there to learn so that they could go home and teach better. The United States Government had many officials there to tell them how the Government relied on them.

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*From an address, April 13, 1920, before the Engineers' Club of Philadelphia.

The Bureau of Mines issues bulletins on the conservation of fuel in the house, and I venture to say that in these times, when fuel ought to be saved, the householders of the country do not know about these bulletins.

Activities of National Technical Societies.—This lack of putting information across is also true of the national technical societies. We think because we know about their bulletins that the other man who ought to know and who ought to use them should use them. Every one of these organizations ought to have national committees of publication to spread the gospel and let the people know. The same way with our local organizations. All through the year we are holding meetings on illumination, heating and ventilating, and here in the club on city planning and zoning and on building codes and other vital subjects affecting the safety of the people, and what is the result? We have perhaps 30 members, sometimes 25; 35 is a good attendance when we discuss a subject like building codes, and we ought to have 300 or 400. Every engineer is interested in building codes and illumination and in school buildings. There was a talk here by Mr. Luckiesch, the noted authority on illumination in schools, and there were just three architects there.

Why should not some co-ordinating committee let all the other organizations know what is going on? Someone here and there would always be found interested and would want to know more about these things and go to hear them, and when the meeting is over there should be a form of bulletin intelligently written, gotten up either in co-operation with the press representatives present, or, if they are not present, without them, and handed to the press. The reporters from the press do their very best. They are fine men, as a rule, but they can not catch these technical subjects.

Opportunities in Municipal Affairs.—Take the administrative affairs. We should have public information on the administration of Philadelphia. There should be a bureau of information. It would help all other bureaus in co-ordinating and functioning and keep before the people all the time the facts they ought to know. Take, for instance, when Doctor Furbush discovered the filthy condition of alleys in some parts of the city, due in most cases to tall fences. That condition still exists. As it is now only occasional publicity is given to such things. Such a bureau of public information tells the city of Philadelphia and the citizens who live here what is being done in Chicago, where they have a special organization devoted to the elimination of alleys and slums. In other cities similar activities are taking place all the time, but we do not keep it before our administrative forces and before our papers and ourselves.

As to the matter of fire protection. We had a conference in Director Tustin's office the other day and were talking about providing 15,000 new houses to accommodate the people in an emergency here in Philadelphia, and while we were talking 40 houses were burning down. Every day the shortage is increasing, the number of houses is being diminished, and instead of talking only about building new ones, for heaven's sake let's save what we have, and one way we can do it is by putting into effect the ordinance called "the personal liability ordinance" for loss by fire, which provides that in case of a fire in his house a man has to pay at least the expense pro rata for the cost of the fire engines or the trucks that come to his house to put out that fire. This sounds drastic, but it is not a great penalty. It is only what the individual ought to do, and the effect is that every householder becomes a good housekeeper and things are kept in such shape that fires are less likely to occur, or if they do they are not likely to spread. Abroad we have 10 times less fire loss than we have in this country, and it is due not only to the personal liability clause, but if the fire spreads from one place to another, the one in whose building the fire starts is liable for all adjoining properties, and you may be sure that such a one is extremely careful that the fire does not start in his place.

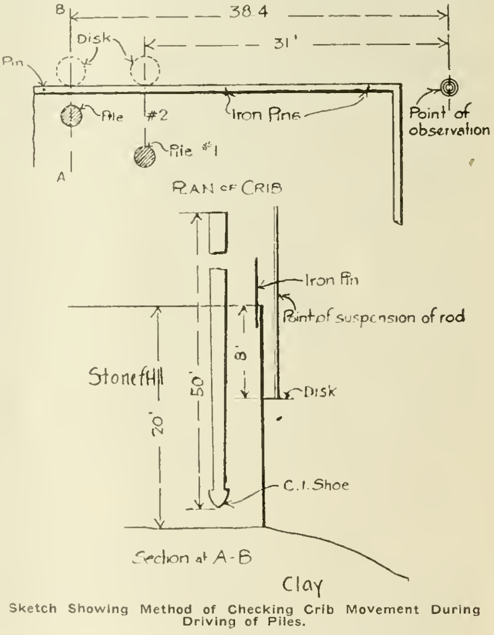
Structural Interests.—There is one thing I should like to say, and that is I would not want a better opportunity than to be an editor of one of our Philadelphia newspapers—any one to organize a department that would feature every day or two the activities within the structural interests, or what you might call the interests which are concerned with the sheltering of humanity. I would not only have real estate transactions and deeds recorded and all that sort of thing which you can always find by looking from the front of the newspapers backwards. (When you come to the poetry section you know the next one will be the real estate and building.) There is, however, very little published about architectural beauty.

To the newspapers in Philadelphia I would like to throw out the suggestion that in the New York Herald they will find every Sunday a pretty fine article on city zoning and what it means to all communities. All this is public information. It is simply called "public information," but it covers the whole of God's country, and it is broad enough to claim the interest of every one.

Method of Checking Movement of Crib Through Which Piles Are Driven

In order to determine just what movement takes place when piles are driven through the crib ballast, two test piles were driven through 20 ft. of the stone of a timber crib. The test was made by Mr. S. J. Chapleau, District Engineer, Ontario Department of Public Works. The method of checking the movement of the faces of the crib during the driving of the piles is described by Mr. A. Langlois in the Contract Record.

In carrying out the experiment a trestle or stand was erected on which was attached a pole supporting a disc and the transit. The method of making the observations is evident from the sketch. Two 50-ft. piles were driven for their full length, 20 ft. through the stone of the crib work and the balance through clay. The piles were shod with cast iron shoes and banded at the butt with an iron ring. A 200-lb. hammer was used for driving. The result of the experiment was most satisfactory, one pile being driven as close as 12 in. from the face of the pier, with a slight move of hardly ¼ in. recorded on the top two timbers. During the driving of pile No. 1 not the slightest move was detected.

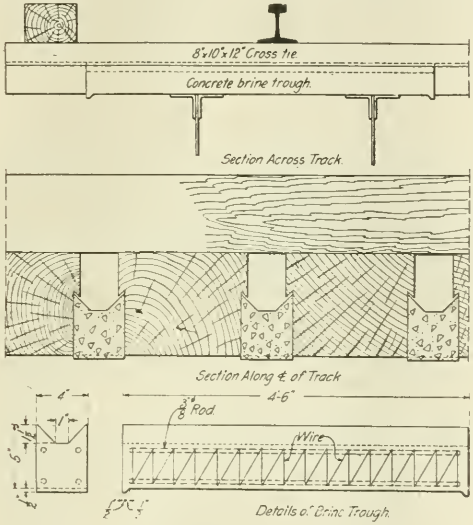


Sketch Showing Method of Checking Crib Movement During Driving of Piles.

Fabricating Shops Contracts in May.—The records of the Bridge Builders' & Structural Society, from reports collected by its secretary, show that during the month of May 61½ per cent of the entire capacity of the bridge and structural shops of the country was contracted for.

Concrete Brine Troughs for Bridge Decks

Experiments are now being carried out by the Michigan Central R. R. with concrete troughs as a means for protecting open floor steel railroad structures from the action of salt brine. The scheme is described by Mr. J. E. Bibb, Assistant Bridge Engineer, in a recent issue of the Railway Maintenance Engineer. It is the intention to use this particular type of brine trough on bridges having shallow girders or I-beam stringers, the brine being allowed to drip from the end of each trough at the center of the track. Where, however, the girders or track stringers are of considerable depth and the action of the wind would tend to blow the brine against the girders, it is proposed to use a light reinforced concrete trough, suspended longitudinally from the ties with iron straps. A wooden down spout placed at the end of the trough will carry the brine below the girders.



Details of Brine Trough and Method of Application.

The concrete unit will fit between the ties of the bridge, each tie being scored on the sides to fit over the trough, the upper edge of the scoring being given a downward pitch to prevent capillarity. Each concrete unit as now made weighs approximately 75 lb., but the use of slag or cinder concrete will reduce this weight to about 55 lb.

There is no doubt but that the best results in the framing or scoring of the ties will be obtained when this is done at the mill or shop before shipment to the bridge where they will be used. But this same result can be obtained when done in the field by the ordinary bridge carpenter with the usual tools, so that in the conduct of these experiments it has not been found necessary to order specially scored ties, the usual stock tie being used. Great care has been found necessary in the handling of the concrete units just after the removal in the forms to prevent injury to the feather edges of the troughs, since bad nicks will render a trough useless. As soon as the forms are removed each unit is given a thorough rubbing with a carborundum brick.

Sufficient time has not elapsed to form any definite opinion of the serviceability of this scheme. There is no doubt that the trough will carry off and resist the action of the brine satisfactorily, but whether it will stand up under the vibration of the bridge remains to be seen. The idea of the concrete brine trough was conceived by J. S. Huntoon, assistant bridge engineer of the Michigan Central, and it is under his supervision that the experiments are being conducted.

Standard Lengths, Sizes and Quality of Lumber as Related to Economic Designs

Suggestions for securing more efficient design and application of lumber in building are given in a leaflet issued recently by the Architectural and Building Code Service of the National Lumber Manufacturers' Association. The suggestions follow:

Since labor has become a most significant factor in the cost of building, and since there are certain established standards of lengths and sizes, as well as significant differences in grades of lumber, it is important that the use of these standard lengths, sizes and grades be intelligently applied to the design of buildings for the purpose of reducing the cost of construction where possible.

In designing the floor plan of a building, the fact that standard lengths of joists are multiples of 2 ft., 4 ft. to 24 ft. inclusive, should be an important consideration in determining the widths and lengths of each room.

Odd lengths, such as joists, 9, 11, 13 and 15 ft., not commonly carried in stock, are charged as the next longer even length and cut at the lumber yard before delivery, or delivered in the next longer even length, necessitating cutting by the carpenter on the job. The waste here is obvious, both in material and in labor, and could easily be avoided by careful design.

A building does not necessarily have to be an even number of feet in width in its over all dimension. Take, for example, a brick building, which is built 24 ft. wide with 12-in. walls. Joists which are 25 ft. long can be used, but at least 16 in. must be cut from the ends to have the proper extension of the joist ends in the brick wall, whereas, if the building had been built 25 ft. 4 in. wide, 24-ft. joists could have been used with no waste, or by decreasing the width but 8 in., 22-ft. joists could have been used.

When designing heights of stories, whether in braced or balloon frame, ordinary or other types of construction in which wooden studs are used, standard lengths are quite as important a consideration as joists, and economy may be practiced with the same result. To be sure, 9-ft. and 11-ft. lengths may be cut from 18-ft. and 22-ft. lengths, respectively, but why necessitate even this amount of additional labor when avoidable?

Whether the schedule of lumber ordered be large or small, if the material listed be of standard instead of odd lengths, a material saving, as well as more prompt delivery is assured.

It should also be remembered that whenever the size of lumber is given in whole numbers, such as, 2x4, 2x6, 2x8, etc., standard commercial or nominal sizes are meant; but whenever the size is given as 1⅝x3⅝, 1⅝x5⅝, 1⅝x7½, etc., actual sizes are meant, and stresses should always be based on actual size of material used.

In the selection of materials, particularly of timbers and wooden beams to be used in building, care should be exercised to select good, sound materials, free from rot, large or loose knots, shakes or any imperfections whereby the strength may be impaired, and of such size and dimensions as are required for the kind of building erected.

Upon ascertaining from your lumber dealer the prices per 1,000 ft. of several sizes and lengths of lumber, it is a simple problem in mathematics to determine whether it will be more economical to use 16 lengths of 2-in. x 8-in. joists, 16-in. centers in the floor construction under a certain room, or to use 12 lengths of 2-in. x 10-in. joists, 20 in. on centers, for the same purpose, and similarly, of two lengths of 2-in. x 4-in. studs 8 ft. long, can be used more economically than one length 16 ft. long and answer the same purpose. Care should also be exercised in the design of roofs, so that the pitch of the roof and the projection of the cornice or eaves is so arranged as to use even lengths of materials for rafters.

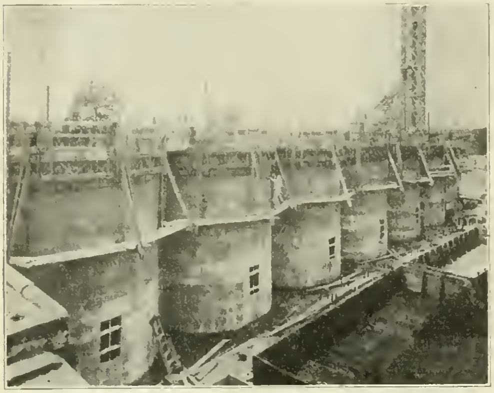
As the flooring for porches is generally laid at right angles to the house proper, the width of the porch should be such that material here will cut also to the best advantage.

If these few points are adopted by architects, engineers and contractors, to make more efficient the design and application of lumber in building, much waste can be avoided and a considerable reduction in cost of construction will result.

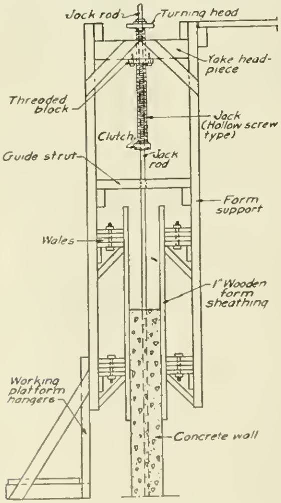
Slip Form for Circular Concrete Construction

A slip form that is stated to be especially useful for circular concrete work, such as standpipes, water and grain tanks, as well as chimneys, is described by Mr. J. Metz, Superintendent James Stewart & Co., Contractors, in the June Contractor's Atlas. The cross section gives a good idea of the construction of the form and its method of operation.

The sliding form is about 4 ft. high. An inner form similar to the outer one is attached to the latter by an overhead yoke. A jackscrew running through this yoke raises it and the two forms simultaneously.


Slip Form in Operation at St. Louis Grain Elevator.

These jackscrews are fastened by a gripping device to vertical rods which are put up, one section at a time, the sections being connected by sleeves. The rods are allowed to remain in the concrete wall as a part of the reinforcing. These jacks are placed at close enough intervals so that the forms are pulled up evenly all around. As the work advances all the jacks are given a certain number of turns at the same time, the forms thus being raised gradually and uniformly over the whole piece of work.



Cross Section of Slip Forms.

This form was used by the James Stewart & Co. in the construction of a grain elevator for the Valies & Spies Milling Co., St. Louis, the job consisting of 18 grain tanks, 20 ft. in diameter and 118 ft. high with 10 interstice bins and a work-house 30 ft. by 40 ft.

This work-house contains 16 bins 85 ft. deep and with operating and machinery rooms runs up to a total height of almost 200 ft.

In order to avoid any joints in the concrete the work was carried on continuously night and day. Concreting was started on the storage tanks and 11 days later they had been completed to the full height of 118 ft. The greatest distance the forms were raised in any one day was 13 ft. The work-house was built to the height of 195 ft. in 18 days—an average of about 11 ft. a day.

Light Creosote Oils in Wood Preservation

Light creosote oils properly injected into wood apparently will prevent decay until the wood wears out or until it checks so badly that the untreated portions are exposed. Such is the indication of service records collected by the Forest Products Laboratory on railway ties and telegraph poles preserved with low boiling creosotes.

Creosotes used in ties from 25 to 50 years ago were for the most part oils having 50 per cent or more distilling below 235° C., with a residue not to exceed 25 per cent at 315° C. The ties so treated lasted from 15 to 20 years, and failure was traceable in most cases to mechanical wear, such as rail cutting and spike killing. In no case was failure found to be the fault of the preservative.

Of 1,558 telegraph poles in the Montgomery-New Orleans line, which were pressure-treated with a light creosote oil, 1,049 poles were still sound after 16 years. In 91 per cent of the cases of decay, the fungi had entered the wood through checks and shakes. Representative sections in the Norfalk-Washington line showed that after 17 years' service, of the 1,614 poles inspected, 1,469 were sound, 92 decayed at the top, and 105 decayed at the ground line. The decay at the top was caused chiefly by cutting off the poles. In those decayed at the ground line, the causes of failure, as determined in 88 per cent of the cases, were checks or shakes. Here again, as in the ties, the preservative outlasted the mechanical life of the wood.

According to the June Technical Notes of the Forest Products Laboratory, unless some other factor than protection from decay is considered important, therefore, there is apparently no need to specify high boiling oils. The important point is that any coal tar creosote which is not extremely low boiling or extremely high boiling will satisfactorily prevent decay, and in the selection of an oil, factors such as price, penetrability, and convenience in handling should receive greater consideration than moderate differences in volatility.

Effect of Alkali Soils and Waters on Concrete

The tests made during the past year by the U. S. Bureau of Standards in its investigations of the workability of Concrete in alkali soils and waters, according to the technical news bulletin of the bureau, tend to confirm the conclusions, as previously stated in Technologic Paper No. 95; but final conclusions, as to the resistance of concrete to the action of various types of alkali waters cannot yet be drawn from the data now on hand. One interesting point, however, which has been definitely brought out by this work, is the marked variation in concentration of salts which may be found in the soil short distances apart. Tile placed in the highly concentrated portions or receiving seepage water direct from such areas may be exposed to concentration several times as great as similar tile which may happen to be placed further down the drain. The highest concentration of seepage water is not made apparent by analyzing the water collected at the outlet of the drain. Analyses of samples of soils and borings distributed over a tract of land previous to installing a drainage system may give a fairly good idea of the type of salts and the average concentration to which the tile later may be exposed, but there is no assurance that in small localized areas much higher concentration may not be found, or may not develop through a change in drainage conditions. As a type, sulphate waters appear to be most destructive to concrete, the severity of action seeming to vary with concentration of soluble salts. The wide variation in quantities of the various constituents found indicates that action is not greatly dependent upon the presence or absence of any one constituent of water in which a large quantity of the sulphate is present.

Results of Tests of Strength of Gunite Slabs

Tests completed recently under the supervision of Prof. M. O. Fuller, of Lehigh University, bring out interesting information regarding the strength of gunite. The tests were made by putting a platform on top of rollers carried on ¾ in. by 3 in. straps, placed at one-third points. Pig iron was piled on top of the platform and deflections read at each addition of about 500 lb.

The first tests were made on slabs of gunite 2 in. thick and 4 ft. clear span. The slabs acted as simple beams, free at each end. The reinforcing mesh was an expanded metal from the Consolidated Expanded Metal Co. It was 2¼ in. mesh and was placed at ⅜ in. from the bottom of the slab. These slabs were shot Dec. 22-23, 1919, and were broken Jan. 20-21, 1920. A summary of these tests is given in Table I.

The second series of tests was made on gunite slabs 3 ft. 9 in. wide and 6 ft. clear span, acting as a simple beam. All gunite was 1 part sand, 3 parts cement before mixing. Cement made up equal parts Lehigh-Atlas-Alpha-Penn-Allen. Steel reinforcemtnt was expanded metal, 2¼ mesh, supplied by Consolidated Expanded Metal Co., The actual weights of mesh were: 0.30, 1.16 lb. per square foot.; 0.25, 0.94 lb.; 0.20, 0.78 lb.; 0.15, 0.63 lb. Attention is called to the fact that steel is very much above the intended plane, thereby reducing the effective depth. This shows the necessity of providing proper methods of supporting and holding the steel as the action of the "Cement Gun" tends to raise the steel mesh. Slab No. 30 is excellent example of probable results that would have been obtained had steel been held in proper platform. The slabs were shot Feb. 13-14 and were broken March 12-13. Table II summarizes the result of the tests.

TABLE I—SUMMARY OF TESTS ON GUNITE SLABS, 2 IN. THICK, 4 FT. CLEAR SPAN.

	Slab mixture before placing in "Gun."	Rein. sq. in. per ft. of width.	First deflec. at lb.	Last deflec. at lb.	Brake at lbs.	Equiv. lb. dis. load.	Per sq. ft.
1	1-3	0.20	1/16-2,775	11/16-11,440	12,353	16,469	823
2	1-3	0.20	1/16-3,360	5/8 - 9,716	10,301	13,735	687
3	1-3	0.20	1/16-2,606	5/8 -11,292	11.232	15,776	789
8	....1-2½	0.20	1/16-2,877	9/16-12,429	13,130	17,507	875
9	....1-2½	0.20	1/16-3,261	5/8 -11,832	12.493	16,657	833
10	....1-2½	0.20	1/16-3,220	5/8 -10,001	10,394	13,859	693
4	1-3	0.10	1/16-.....	7/16- 6,798	7,373	9,831	492
5	1-3	0.10	1/16-3,331	1/2 - 8,556	9,040	12,053	602
6	1-3	0.10	1/16-3,906	7/16- 8,466	9,128	11,410	570
7	....1-2½	0.10	1/16-3,861	7/16- 8,378	9,500	12,667	633
11	....1-2½	0.10	1/16-3,180	5/8 - 8,372	8,847	11,796	598
18	....1-2½	0.10	1/16-4,373	9/16-10,124	10,705	14,273	714
12	1-3	0.15	1/16-2,709	5/8 -10,111	10,465	13,593	698
13	1-3	0.15	1/16-3,218	5/8 - 8,425	8,722	11,629	581
*14	1-3	0.15	1/16-3,758	9/16- 8,130	8,811	11,748	587
*15	....1-2½	0.15	1/16-4,948	3/8 - 9,700	10,453	13,937	397
19	....1-2½	0.15	1/16-4,371	9/16-10,176	11,184	14,912	745
*20	....1-2½	0.15	1/16-4,649	5/8 -11,532	11,915	15,887	794

Remarks:

Thus slabs with 0.20 reinforcement have a safe load of 157 lb. per square foot with a factor of safety of 5, or 190 lb. with a factor of safety of 4.

Slabs with 0.10 reinforcement have a safe load of 120 lb. with a factor of safety of 5, or 150 with a factor of safety of 4.

Slabs with 0.15 reinforcement have a safe load of 134 lb. with a factor of safety of 5, or 168 with a factor of safety of 4.

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*Broken on Jan. 31, 1920.

TABLE II—SUMMARY OF TESTS OF GUNITE SLABS; SIMPLE BEAM 6 FT. CLEAR SPAN.

Slab No.	Act. thickness, In.	Rein. sq. in. per ft. width.	Dis. of steel from bot., in.	First def. wt. and lbs.	Equiv. unif. dis. load. at first def.	Last def., wt., lbs.	Applied break load.	Equiv. unif. dis. load.	Breaking load per sq. ft.	Average for each group.
21	...2	0.25	3/4	1,600	94	1 1/16-5,058	5,750	7,667	341	...
22	...2	0.25	5/8	1,550	92	1 1/16-4,359	5,115	6,820	303	315
23	...2	0.25	3/4	1,556	92	1 1/16-4,316	5,051	6,735	300	...
24	...2½	0.25	9/16	2,033	120	1 -7,133	7,903	10,537	468	...
25	...2½	0.25	13/16	1,577	93	15/16-7,281	7,821	10.428	463	477
26	...2½	0.25	5/8	2,689	160	1 -7,833	8,415	11,220	499	...
28	...1 7/6	0.15	9/16	.....	...	....	4,817	6.423	286	...
29	...2¼	0.15	5/8	1,600	94	1 -4.481	4,810	6,420	286	...
30	...2¼	0.15	3/8	2,085	124	1 -5,444	5,839	7,785	346	316
31	...2	0.30	11/16	1,530	99	1 1/16-4,845	5,555	7,407	330	...
27	... ..	0.30	.....	2,170	129	....	.....	.....	...	...
34	...2½	0.30	11/16	2,076	123	1 -7,634	8,632	11,509	511	543
35	...2½	0.30	3/4	2,588	153	1 -9,135	9,702	12,956	575	...

Remarks:

Slab 21. Slab broke at one third point. Very clear fracture of Gunite. Steel pulled apart in straight line.

Slab 22. Broke at third point. Steel pulled apart. Clear fracture of Gunite. Slight scaling on upper corners of break.

Slab 23. Same as Slab 22.

Slab 24. Broke at third point. Very clear fracture. No scaling. Steel pulled apart on straight line.

Slab 25. Same as Slab 24.

Slab 26. Same as Slab 24.

Slab 28. Do not place much reliance on this result as found that steel form was still under slab (not supported). Slab broke when plate was removed.

Slab 29. Same as Slab 24.

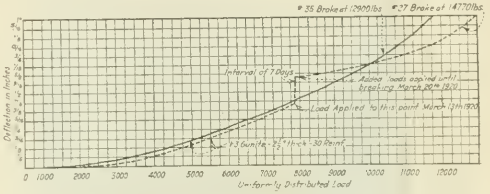
Slab 30. Broke in center. Very clear fracture. Steel pulled apart in center.

Slab 31. Broke at third point. Steel not broken. Failure evidently due to elongation of steel as slab below steel was forced out. Only slight scaling on upper (Compressor) side.

Slab 27. This slab loaded to 6,211 lb. (368 per sq. ft.). When deflection was 7/16 in. and then left for future examination.

Slab 34. Broke at third point. Steel broke about half way across showing evidently steel failure. Gunite had slabbed at top edge. No other sign of weakness.

Slab 35. Same as Slab 31.



Deflection Curves of Gunite Slabs, 6 ft. Span, 3 ft. 9 in. Wide—22½ sq. ft. Slab No. 35 Was 29 Days Old, Slab No. 27 Was 36 Days Old When Second Loading Was Applied.

Tests also were made of slabs of 6 ft. and 8 ft. The further tests for the 6 ft. slabs were made to get definite proof on the previous test where the steel had been placed too high.

The results obtained on the other slabs seem to justify the belief that the proper proportion of steel necessary to produce a true composite slab of gunite is about 1.60 per cent, and that a proportion ranging from 1.75 to 2.00 per cent will produce a slab that will fail by compression.

A notable fact about the series of tests made on the 4t., 6 ft. and 8 ft. spans is that, although shot under different conditions, at different times, and by three different "Cement Gun" operators, the results are almost identical.

A summary of the tests on the 6 ft. and 8 ft. spans is given in Table III. These slabs were shot April 9-10 and were broken May 7-8.

Indiana Contractors' Relief Law Constitutional.—Judge Miller, of the Johnson Circuit Court at Franklin, has ruled that the law enacted by the last legislature of Indiana providing for the release of road and bridge contractors from their contracts with the county, where it is shown the work would be done at a loss under the contract price because of increased cost of materials and labor, is constitutional.

TABLE III—SUMMARY OF TESTS ON GUNITE SLABS OF 6 FT. 8 FT. SPAN.

Slab No.	Clear span, ft.	Rein. sq. ft. per width.	Total slab thick, in.	Steel from top effec. depth, in.	Per cent of steel.	Load sq. ft. at first def., 1/16 in.	Last def. read. in.	Breaking load sq. ft.
36	6	0.15	2	1 7/16	0.87	90	2	257
37	6	0.30	2	1½	1.66	94	2¼	400
43	6	0.30	2⅛	1 11/16	1.48	60	1⅜	394
44	6	0.30	2	1 9/16	1.60	57	1⅞	387
45	8	0.40	2½	2	1.67	70	3	390
46	8	0.40	2⅝	1 15/16	1.73	94	3	348
48	8	0.40	2⅝	2⅛	1.57	57	2½	420
41	8	0.50	3	2	2.08	90	1¾	492
42	8	0.50	3	2¼	1.85	86	1⅝	534
47	8	0.50	2⅞	2¼	1.85	89	2¾	447
38	8	0.60	3⅛	2⅝	1.90	65	3¼	614
38	8	0.60	3⅛	2½	2.00	112	2½	607
40	8	0.60	...	....	....	110	...	...

Remarks:

Gunite: 1 part cement, 3 parts sand.

Rein. mesh. Expanded metal furnished by Consolidated Expanded Metal Co.

Slab 36. Steel failure. Clean fracture of Gunite.

Slab 37. Steel failure. Clean fracture of Gunite.

Slab 43. Failure of both steel and Gunite. Slight diagonal tension cracks. Several steel strands broken.

Slab 44. Failure of both steel and Gunite. Slight diagonal tension cracks. Several steel strands broken.

Slab 45. Gunite failure. Diagonal tension cracks.

Slab 46. Gunite failure. Diagonal tension cracks.

Slab 48. Gunite failure. Diagonal tension cracks.

Slab 41. Steel failure. No indication of diagonal tension.

Slab 42. Composite failure. Few steel strands broken. Slight diagonal tension cracks.

Slab 47. Gunite failure. Diagonal tension cracks.

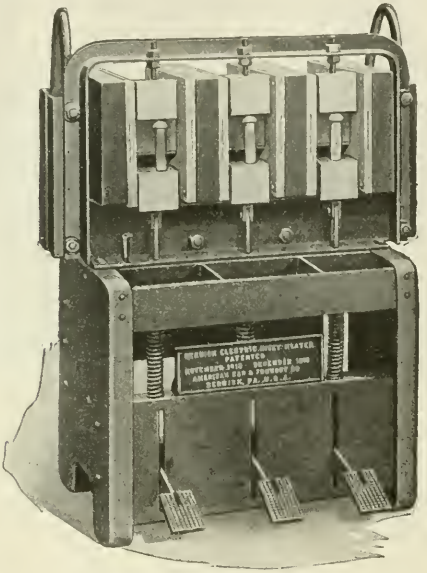
Slab 38. Composite failure. Few steel strands broken. Diagonal tension cracks.

Slab 39. Gunite failure. Diagonal tension cracks.

Slab 40. This slab loaded to 445 lb. per sq. ft. (1 in. def.) and left for future reference.

An Electric Rivet Heater

Electric rivet heaters were designed and perfected by American Car & Foundry Co., 165 Broadway, New York, during the past six years, to improve working conditions in its own shops. Daily use developed so many valuable features that several outsiders, who had seen the heaters in operation, asked that they be marketed. This was done, in 1919, and eleven standard Berwick electric rivet heaters, for various rivet sizes and capacity requirements, are now available. It is claimed that with this heater burning and scaling spoilage of rivets has been reduced to less than ½ of 1 per cent, effecting a saving of about 40 ct. per 100 lb. of rivets heated. The heater consumes less than 20 K. W. hours per 100 lb. of rivets heated. The heaters are furnished with from two to five electrodes, or more, according to the capacity required, for various sizes of rivets up to 1½ in. by 10 in. or larger. Capacity depends upon sizes of rivets and types of heaters, varying from 75 to 600 hot rivets per hour. Using less than maximum capacity does not increase the cost of heating; single rivets can be heated on a five-electrode heater with the same current consumption per rivet as though the heater were running at full capacity.



The Berwick Electric Rivet Heater.

Itemized Costs of Houses Built in 1915. 1919 and 1920.—In a letter in a recent issue of The Improvements Bulletin, H. A. Sullwold, Architect, St. Paul, Minn., gives the following figures as showing the comparative costs of houses bids for which were taken in 1915, 1919 and 1920:

House A—1915. Cost, $4,250; 30,855 cu. ft.; cost $.137 per cubic foot.

House B—1919. Cost, $8.399; 33,264 cu. ft.; cost, $.252 per cubic foot.

House C—1920. Cost, $11.820; 32,978 cu. ft.; cost, $.358 per cubic foot.

ITEMIZED COST.

	House, 1915.	House, 1919.	House, 1920.
Excavation, foundation, etc.	$ 750	$1,485	$1,950
Lumber	517	1,300	2,089
Millwork	915	1,790	2,950
Plastering and insulation	732	850	1,295
Tinning	70	100	136
Painting	280	300	895
Carpenter labor	700	1,200	1,800
Bond	25	125	230
Ironwork	51	125	None
Insurance (workmen's compensation)	None	75	100
Tilework	None	675	None
Hardware	200	375	*375
Totals	$4.250	$8.399	$11,820

*Poorer quality.

In the 1920 house many changes were made in the specifications to bring the cost down; no oak flooring, No. 2 fir sheathing in place of pine, No. 2 fir studding in place of pine, same grade. There was no tilework in the 1915 or 1920 houses. This was due to the fact that the sunporch in 1919 house and bathroom was tiled. Linoleum furnished by owner was used in baths in other two.

Personals

William Barclay Parsons, consulting engineer, New York City, has had the degree of doctor of science conferred upon him by Princeton University.

E. S. Nettleton has been appointed acting city engineer of New Haven, Conn., succeeding F. L. Ford, who resigned recently, as noted elsewhere in this column.

Peter L. Sala, architect, has been appointed building inspector of Stockton, Calif., succeeding Richard Noall, who resigned to re-enter the contracting business.

Earl E. Chadwick, formerly with the Department of Public Works, Minneapolis, Minn., has been appointed city engineer of Winona, Minn. Henry E. Wolff, for several years city engineer of Winona, recently severed his connections with the city to enter private practice.

Arthur F. Barnes, formerly dean of the engineering department of New Mexico State College, has become associated with Barglebaugh & Whitson, architects and consulting engineers, El Paso, Dallas and Houston, Tex., as mechanical and industrial engineer and manager New Mexico-Arizona District.

Roscoe Smith, who for the past year has been associated with J. F. Druar in the capacity of consulting engineers at offices located in the Globe Building, St. Paul, Minn., have dissolved partnership. Mr. Smith has engaged his services to the National Board of Fireproof Underwriters, with headquarters at New Orleans. His territory will extend over Missouri and joining southern states.

F. L. Ford, for the past 8 years city engineer of New Haven, Conn., has resigned that position to become vice-president and general manager of the Connecticut National Pavement Company, Inc., New Haven, Conn. This company is to promote, contract for, and lay National pavements in the states of Connecticut and Rhode Island.

Harvey Dartt has resigned the position of city engineer of Mankato, Minn., and has engaged his services to the Barrett Paving Co., Minneapolis, Minn. Mr. Dartt has been for the past 20 months city engineer of Mankato and for several years prior was city engineer of Owatonna, Minn. He has had a wide experience in paving and general municipal improvements and will act as a district engineer for the Barrett Co. in the promotion of Tarvia pavements.

Industrial Notes

The Koppel Industrial Car & Equipment Co., Koppel, Pa., has opened a district office in the Book Bldg., Detroit, Mich., with H. D. Mercer as district manager.

Employes of the organization of Morris Knowles, Inc., engineers of Pittsburgh, Pa., recently held their regular annual outing. Races and a baseball game were features of the afternoon and many of the 200 employes, their families and friends participated. Besides the local attendance, there were present R. F. McDowell of the Cleveland Office: W. Wade Shidler of the Youngstown Office, and several employes of the Windsor, Ontario, Canada, Office.

The Milliken Brothers Mfg. Co., Inc., New York, manufacturer of all-steel industrial buildings, as well as other structural steel specialties, including transmission towers, radio towers and poles, will devote the greater part of its operations in the future to the production of buildings. The general headquarters, heretofore located on the 18th floor of the Woolworth Building, New York, have been removed to larger offices on the 20th floor of the same building.

Whitfield P. Pressinger, New York, vice president, Chicago Pneumatic Tool Co., died June 10th as a result of complications following an operation. Mr. Pressinger was actively engaged in the pneumatic tool and allied machinery industry for many years. He was general manager of the Clayton Air Compressor Co. for seven years and became widely known through numerous activities in the American Society of Mechanical Engineers and the Compressed Air Society. He was born in New York City in 1871.

The Chicago Pneumatic Tool Co., New York, announces the election of Allan E. Goodhue as vice president in charge of sales. Mr. Goodhue, since May 1, 1919, has been managing director of the company's English subsidiary, The Consolidated Pneumatic Tool Co., London, England; also director of European sales for the Chicago Pneumatic Tool Co. Mr. Goodhue was formerly for a number of years connected with the sales department of the Midvale Steel Co. and Midvale Steel & Ordnance Co. in Philadelphia, Chicago and Boston, leaving that company in March, 1918, to enter the service of the Government. From that time until Jan. 1st, 1919, when he became connected with the Chicago Pneumatic Tool Co., he was assistant manager of the steel and raw material section, Production Division, of the Emergency Fleet Corporation. Mr. Goodhue sails for New York on the "Olympic" and is scheduled to arrive in New York about July 3rd.

Obituaries

George W. Key, a contractor of Asheville, N. C., died June 15, aged 66.

Beverly R. Value, civil engineer, died June 12, aged 56. He was engineer in charge of the construction of the New Croton dam of New York City, and also superintended the building of several New York subway lines.

Willard Thomas Sears, an architect of Boston, Mass., died May 21, aged 83. Mr. Sears' work was carried on in many cities of the United States, as well as in South America and Hayti. He rebuilt the cathedral at Cape Haytien.

Owen E. Seip, 85 years old, a contractor, who built more than 500 buildings in Atchison, Kan., and hundreds in Kansas and Nebraska towns from 1857 until 1915, died June 16 at his home in Atchison. He was born in Pennsylvania and with his bride came to Atchison in 1857, crossing the Missouri River at St Joseph and coming to Atchison by stage coach on the Kansas side.

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Roads and Streets—1st Wednesday
(a) Roads
(b) Streets
(c) Street Cleaning
(d) Municipal Miscellanies
(e) Management and Office System

Waterworks and Hydraulics—2nd Wednesday
(a) Waterworks
(b) Sewers and Sanitation
(c) Irrigation and Drainage
(d) Power and Pumping
(e) Management and Office System

Railways and Excavation—3rd Wednesday
(a) Excavation
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(d) Steam Railways, Construction and Maintanance
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Buildings and Structures—4th Wednesday
(a) Buildings
(b) Bridges
(c) Harbor Structures
(d) Miscellaneous Structures
(e) Properties of Materials
(f) Management and Office System

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The Index for Vol. LIII—January-June, 1920—issues of Engineering and Contracting is now being prepared. In common with many other publishers we have adopted the practice of sending the index to only such subscribers as request it. Therefore, if you want the index for the last 6 months you should notify us at once. Those who requested the index for the previous volumes have been listed and need not notify us again.

Education of Employes to Counteract Marxian Theories

Editorial in The Engineering Review, London.

If we examine the cases where profit-sharing of one sort or another has been established successfully, we find that they are generally either small factories, where the owner is in personal contact with all his men, or industries of a stable unvarying character in which a strong corporate life has slowly developed. In both groups we may discover a process of education which has brought the workers to realize the identity of interest which exists under all systems of payment. Behind every device for dealing with unrest and diminished will to work lies the need of enlightenment. Anyone who takes the trouble to read what workmen read will be aware that they have thoroughly soaked their minds in the fallacies of Marxian economics. These fallacies are admirably calculated to appeal to men who feel, like most of us, that the world does not treat them as well as they deserve, and who are continually reminded of the black pages in the history of capitalism. It is upon this mass of misunderstanding that the Industrial League and other bodies are persistently working. The process is a slow one, as every process of disintegrating tradition by fact and error by reason must be; and possibly the present generation may not see any very conspicuous results from the co-operation of employers and employed in the field of instruction. But the very slowness of the process affords a reason for supporting and encouraging it. Every employer can do something towards educating his own employes, either personally or by proxy. The personal method is open to the directors of a small undertaking; in a large factory it is necessary to rely upon works committees and the distribution of literature. The house organ is a good example of the use of literature as a corrective. In addition to publishing shop news, this magazine deals briskly and informingly with live economic questions, and it must have some effect in enlightening the employes on matters which the average workman would dismiss with a Marxian formula.

The Earliest Chlorination of Water in England

Editorial in Municipal Engineering, London, May 27, 1920.

In a letter in our correspondence columns Mr. Leslie C. Walker, Engineer and manager to the Reading Corporation Water Works, claims that the chlorination of water was first applied on a practical scale at the Reading Water Works in the year 1910. It will have been seen from the numerous references we have made to the subject for some time past that Dr. Houston, Director of Water Extensions to the Metropolitan Water Board, has been credited with the introduction of the system into this country, and for its use in the purification of the water supplied to London since 1916. Mr. Walker supports the claim for Reading by the statement that in 1911 the Reading method was personally examined by Dr. Beaton, the chairman of the water examination committee of the Metroplitan War Board, who congratulated him on the results obtained. While it is just that Mr. Walker and the chemists associated with him should be awarded the credit for the practical application of this startling discovery of the sterilization of water by chlorination, if such can be established, we should like to point out that Mr. Joseph Race, in his book, "The Chlorination of Water," states that the credit for the first systematic use of chlorine in water disinfection is due to Dr. Houston, with Dr. McGowan, who in the typhoid epidemic at Lincoln in 1904-5 sterilized the reservoirs and distributing mains, etc., with it with entirely satisfactory bacteriological results.

The Origin of the Activated Sludge Process of Sewage Disposal

Editorial in The Surveyor, London, Feb. 27, 1920.

In an extract from the annual report for the year 1917 of the Lawrence Experiment Station, Massachusetts, printed on another page, the statement is made that the activated sludge process "is essentially a Lawrence process." All workers in sewage disposal willingly recognize the great value of and advantages derived from the experiments which have been carried out for so many years at the Lawrence Experiment Station, but common fairness to workers in Great Britain demands that certain facts should be restated in connection with this matter. From the above statement in the Lawrence report it might be inferred that the activated sludge process was discovered and developed at the Experiment Station. On the other hand, anyone conversant with the Lawrence reports for 1912 and 1913, and with the paper by Clark and Adams, Feb. 7, 1914, will be able to see the line taken by Clark and his coworkers, and a careful perusal of Ardern and Lockett's first paper will show not only that Lawrence work was recognized, but where it differed from the Manchester work. Dr. Fowler, in the discussion on Ardern and Lockett's paper, admitted the importance of the experiments he saw at Lawrence, where sewage had been completely purified by 24 hours' aëration, but added that "the idea at that time, and subsequently in the experiments which had been published from that (Lawrence) laboratory, involved the principle of surface." This emphasized the point made by Ardern and Lockett in the paper referred to that "the researches of Clark, Gage and Adams, and of Fowler and Mumford show a marked advance on previous workers; but it will be seen that, in the case of the former investigators, the idea of surface contact is retained, as evidenced by the construction of the aëration tanks, and in order to produce a nitrated and stable effluent, further treatment is required."

It may be useful to recall that, for several years prior to 1912, Dibdin and others had directed attention to the presence of animal life in the sludge deposited on the slates in slate beds. Following certain observations on the presence of algal growths in aërated polluted waters, Clark records that "Experiments were begun in April, 1912, to test the efficiency of aëration combined with these green growths as a treatment of sewage preliminary to filtration." The results showed that there was little to choose between the sand-filter effluents, the one filter being treated with aërated sewage seeded with green growths and the other with sewage not seeded. Later the sewage was aërated in slate beds, thus doing for Dibdin's slate bed what Lowcock did for the contact beds. It should be noted that the volume of air used is not recorded, and that a blank experiment is not made, so that one is unable to say to what extent the aërated sewage differed from the unaërated liquid under similar conditions. That, however, is by the way; the main point is that a medium upon which abundant growths may occur is regarded as an essential condition, and that the aërated slate-bed effluent, which is little better than a precipitated sludge, required further treatment in filters. A later paper by Clark and Adams (Feb. 7, 1914) gives the amount of air used as 25,000 cu. ft. per hour per 1,000,000 gal., and states that the requisites for purification, in tanks constructed and operated as described in a previous paper, are: (1) Dissolved oxygen, (2) circulation of sewage for a sufficient period of time, (3) sufficient surface of slate or other material upon which abundant growths may occur.

The foregoing represents the position at Lawrence two months before Ardern and Lockett's paper was read at Manchester. The latter investigators broke away at the very outset from the idea that an extended surface was necessary. They knew, as many others knew, after Adeney's researches, that oxidation of the organic content of sewage would take place by prolonged aëration, but—and this is important—after five weeks' continuous aëration, when complete nitrification had been obtained, the clear liquid was removed, and fresh sewage aërated in contact with the original deposit. There is no question of the effect of animal life or of vegetable growths as distinct from bacterial life, or of a medium for providing an extended surface other than the deposit itself. Further, as the amount of deposited matter increased the time required for each succeeding oxidation gradually diminished. This recognition that the sludge had acquired a new character, had, in a word, become active, is followed up by ascertaining the relation of the volume of activated sludge to sewage treated, and especially to rate of nitrification. It will be observed that the difference between the two methods is not one of degree. In the Lawrence method the sludge or growth is attached to a fixed surface; in the Manchester method, the activated sludge is circulated with the liquid to be purified. Aëration is common to both. As to the claim for development at Lawrence, it was not until February, 1915, nearly 12 months after Ardern and Lockett's paper, that Clark put down an experimental activated sludge tank to be worked on the lines indicated in the paper just mentioned, and the 10 months' observations thereon in 1915 are dismissed in less than a page of the 1915 Lawrence Report. Indeed, it is not too much to say that the credit for the development of the laboratory observations and deductions, and their translation into practice, is due entirely to the Manchester workers.

Shock and Fatigue Tests for Metal

Editorial in The Engineer, London, April 30, 1920.

Anyone who does not realize the very great slowness with which new ideas and principles become incorporated with engineering practice would undoubtedly suppose that the researches of the last thirty years on the effects and mechanism of fatigue and shock would by this time have led to established practice with regard to those designs in which stresses of that character have to be met. Yet this is still far from being the case, and recent discussions both on the choice of steels for automobile parts and on steels for turbine construction have served to show that there is no real unanimity, either as to the tests to be applied to the materials or the interpretation to be put upon their results when they have been applied. In France, Monsieur Fremont has even made an attempt to undermine the "Wohler Law," but it is doubtful that his attempt to discredit researches, apparently mainly because they were the work of Germans, will meet with much sympathy.

The general principle is no doubt widely recognized, as regards fatigue at all events, that a constructional part will survive an indefinite number of applications of an alternating or "repetition" stress provided that the actual stress in the material nowhere exceeds the "true" elastic limit. But in the application of this principle there are two main difficulties; the first is to know the real limits of the stresses likely to arise and the second to know what is the "true" elastic limit. Taking the second point first, it is not yet as widely and fully understood as it needs to be, that the ordinary tensile test furnishes no adequate guide.

The "yield point," which is often vaguely confused with the "elastic limit," has no simple or direct connection with the safe limit of alternating stresses, and even if the refinements of the extensometer are added, no reliable figure can be obtained, since the elastic limit found by the extensometer in a tensile test may depend upon conditions which do not materially affect resistance to fatigue. The only alternative, therefore, is to determine the real "safe range" under alternating stress. Seeing how simple and direct is the "Wohler" test, in which a test bar is rapidly rotated while under load as a cantilever, it is surprising that it is not more widely adopted.

The reason is perhaps to be found in the desire of those arranging a scheme of testing to provide a method which will give an indication of what is vaguely regarded as the power of resisting "shock" as well as the resistance to steadily alternating stresses. It is this desire, which is based on a misconception, which has led to the introduction of a whole series of tests, all of which are more or less unsatisfactory, because they endeavor to measure some complex combination of properties instead of being devised to deal with one fundamental property at a time.

It is, of course, quite true that the "Wohler" test gives no indication of the ductility or lack of ductility of the material; a brittle, high-phosphorus steel may give an excellent result under the simple alternating stress test. The fact, however, does not condemn the test, but merely emphasizes the necessity—obvious enough in any case—that a test for ductility is required in addition to any pure fatigue test. The attempt to combine the two sets of tests into one merely lead to sets of figures which are apt to have very little real meaning.

It is, however, easier to understand the whole matter if it is looked at from the point of view of the manner in which material is actually stressed in service. Here again there is much confusion of ideas as between true fatigue and shock.

Take, for example, the crank shaft of an internal combustion engine, such as is used in an automobile. The ordinary running stresses, which occur once in every revolution during regular service, are of the nature of pure alternating stresses, and their amount and distribution may be very approximately arrived at. The reversals of these regular stresses have to be endured many hundreds of thousands of times during the normal life of a crank shaft, and the part can and ought to be designed so as to resist them, either indefinitely or, if extreme lightness is required, for a known period of service.

From that point of view it is a knowledge of the safe elastic range which is required. But it is admitted that these regular stresses are not the only stresses or even the most severe stresses to which the part may be exposed. A harsh change of gears, for example, may throw a sudden and violent stress on the shaft, or other incidents of rough usage may bring about the same effect. It is obviously very difficult to calculate these stresses, and even when the designer has availed himself of all the experience of similar parts in past service, he must still allow a considerable margin. And it is here that the ductility of his material and its power to resist shock becomes of extreme importance.

The important point, however, is to realize that the two sets of properties are entirely distinct and that they may even be opposed to one another in the sense that increased ductility and shock resistance may only be obtainable at the sacrifice of a high safe elastic range. However exhaustive the system of testing, it will still be for the judgment of the designer to balance the relative advantages of various materials from this point of view. What it is necessary to bear in mind, however, is the fact that the shocks and heavy stresses are relatively few in number as compared with the regular alternating stresses. Taking the crank shaft, which serves as a somewhat extreme example of this point, the material is called upon to resist the ordinary alternating working stresses several thousand times a minute; the heavier shocks due to such causes as gear changing only occur, on the average, at intervals of many minutes. From the point of view of the power of resistance possessed by the material, however, we have here an all-important difference.

A stress very considerably beyond the safe elastic range can still be applied to a material of considerable ductility a very large number of times before rupture occurs—if the true safe range is only slightly exceeded, several hundred thousand repetitions may be safely withstood. On the other hand, if the regular and rapidly alternating working stress exceeds the safe range, failure is bound to result.

The crank shaft which has served as an example is in some respects an extreme case, but it serves to illustrate the point, that two distinct properties are concerned in the safe working of parts of this kind, and that correspondingly our tests should be devised so as to furnish definite and distinct information regarding those two classes of properties.

A test which claims to afford both kinds of information as the result of a single experiment is therefore to be looked upon with reserve. Curiously enough, the safe elastic range, and even the simple "primitive" elastic limit, are data which are only rarely at the disposal of the designer, who is apt to rely upon either the ultimate strength or the yield point as a measure of fatigue resistance. Unfortunately, there is no reliable and direct reation between them, and it has frequently happened—particularly in the case of some very high-tensile alloy steels—that the behavior of a material under alternating stresses in service has been very disappointing as compared with the results obtained from it in the tensile test.

As regards ductility and power of resisting shock, the tensile test is in rather a better position. Elongation and reduction of area do undoubtedly furnish indications which are often quite reliable. Even they, however, present cases—particularly among special heat-treated steels—in which the resistance to shock is alarmingly low in spite of a good "ductility" under steady tensile loading. Although an attempt may be made to explain this weakness away by calling it "notch brittleness," it is none the less highly necessary that the designer should know of it. How important it may prove to be in actual practice, only the experience of service, correlated with extensive records of tests, can hope to demonstrate.

The Duty of Trade Unions to Ex-Service Men

Editorial in Engineering, London, Feb. 27, 1920.

Defective imagination is probably the cause of the opposition which certain trade unions have raised in connection with schemes for the training of ex-service men. . . . Doubtless the opposition has been exaggerated as most political things are, but none the less it certainly exists. It may have a case, but it can be no case which meets the facts. The whole matter is deplorable, and we find it hard that the opposition has been seen in its worst form in connection with the skilled labor branch of the great industry with which we are connected.

In the discussion of this subject in the House of Commons on the 18th inst., Mr. Sexton stated in mitigation of the opposition of labor, that employers were not keeping open the jobs for service men which had been promised and which they had occupied before the war. Mr. Young said something of the same sort. We are not concerned for the moment with those charges. Even if they were proved we could not admit them in evidence. That two wrongs do not make a right is very elementary ethics. The other main argument—we think we may say the other main defense—which was raised was that the amount of employment in the skilled trades concerned was insufficient to justify the inclusion in them of large numbers of ex-service men who had not ben concerned with them before the war. In this we met the main cause of the opposition. It is worthy of discussion and examination, but we think the exercise of a little more imagination by the unions concerned and a little keener recollection of the services they were proposing to ignore would have outbalanced any personal calculations about employment and unemployment. For the sake of ordinary human nature we could have wished that a little risk had been taken.

Although we have indicated, as we hope very clearly, that in our opinion no argument has been advanced which excuses the refusal of certain skilled unions to agree to training schemes for ex-soldiers and sailors, we are quite prepared to admit that the unemployment argument of necessity carries great weight with the labor mind. Unemployment has meant much in many skilled trades in the past, and is the subject of many bitter memories. No great number of years ago the wages in many trades left little or no margin for a rainy day, and periods of slack trade proved hard for many workmen and their families. The feeling of protest against the possibility of the repetition of these experiences has an intensity with the working man which it is difficult for the outsider to realize. This helps to explain an opposition which in some aspects appears almost incredible.

In this matter of unemployment the unions should remember that conditions in the future are never likely to be what they were in the past. Unemployment insurance covering all workers in some form will probably come into being in no great number of years, and in the bill which is being brought forward by the present government all organized workers are covered, except domestic servants and agricultural laborers. This, in itself, practically meets any case which has been raised by the unions which have opposed the training and entry of ex-service men. It is true, or we trust it is true, that under any unemployment scheme which is adopted the out-of-work benefit will not approximate to present wages, and it will not pay even the laziest individual to deliberately remain out of work. The institution of universal out-of-work benefit will, however, take the deepest sting out of unemployment and will make some of the memories of our workmen a record of an experience which their children will never know.

This matter of the getting into civil employment of all discharged navy and army men has, however, another aspect, which is the most important of all. The opposition with which we have been dealing being based on the fear of unemployment bring us to the old fallacy of the work fund. It is said there is only so much of a kind to do, if we admit more men to our union to help to do this work then there will be less for the men who are already in, and consequently they will suffer from more unemployment. The subtlety and danger of this doctrine lies in the fact that in limited and individual cases it may be true. This probably explains its pertinacity. If an isolated firm in a small town has a certain amount of work of a special kind, and they take on a number of extra workpeople to enable them to get through with it, then clearly the work will be finished sooner than if they restricted themselves to their original number of workpeople. Consequently, if the work is not followed up by something similar, the original workpeople may be out of employment at any rate sooner than would otherwise have been the case.

To look at this matter in another and rather broader way. The average amount of unemployment in any industry over a number of years will be a function of the average amount of work to be done in that industry, and the number of workpeople it employs. If by reason of specially high wages or other artificial condition too many workpeople are attracted to the industry, then on the whole the workers of the trade will suffer from more than the average of unemployment. Contrariwise, if an industry for any reason is kept permanently short of labor, and assuming the industry is an important one not likely to die out, then the workers will, on the average, suffer less from unemployment than if the industry was properly staffed. This latter condition sounds attractive to certain labor minds, and it is at the bottom of schemes to limit the number of apprentices and of the opposition to the entry of discharged service men.

We have stated the conditions leading to employment and the unemployment in the above paragraph in a somewhat dangerous way. For the sake of simplicity we have told only half a tale. What we have said is correct, but there are further factors which enormously modify the effect of the simple relations we have considered. No industry can be taken alone, and no body of workpeople can profitably act as though they and their proceedings concerned their particular trade only. To hamper one trade is indirectly to hamper many, and the workpeople who apparently gain by restricting the available labor in their own industry, will themselves suffer in other ways as a consequence. All industry is bound together, and it is to the final advantage of every individual workman that every industry should be as busy and profitable as possible. If, for onstance, the output of machine tools is limited by artificially limiting the number of workpeople available for making them, then either some other industries are prevented from being established or being expanded, or the machinery is made abroad. In either case the workman who thought to help himself suffers directly in the costs of everyday commodities and possibly helps in the undermining of the stability of his own trade in such a way that ultimately he will suffer from more unemployment than he would ever have met in normal seasonal or cyclic variations.

With a keen appreciation of the limitations of human nature we do not wish to preach that the bricklayer should admit dilution in his trade so that the South Sea Islander can buy cheaper calico. We want him to admit dilution so that he himself can buy cheaper shirts. We hesitate to use the word "production." We have seen it in print several times of late. We do, however, wish to point out that if the work fund fallacy is ever to receive its quietus, now is surely the time. The building trade should be object-lesson enough. The work fund in the building trade now stretches beyond the limits of any human vision. The building of houses will lead to the building and extension of factories. The building and extension of factories leading to increased trade and prosperity, will lead to the further building of houses, halls, theaters, etc. This prosperity will also lead to further factories, and will bring into the region of possibility the amazing program for the rebuilding of our hundreds of miles of slums.

There is nothing isolated about the building trade, however. Every productive industry now calls for expanison, and inasmuch as that expansion is achieved, every other industry and every worker in every other industry benefits. One cannot improve on St. Paul in this matter. His images did not refer to the body politic, but his phrases are very applicable. "We have many members of one body and all members have not the same office." . . . "Whether one member suffer, all the members suffer with it! or one member be honored, all the members rejoice with it." There is room and to spare in productive work for every discharged service man in the country.

Roads and Transport in India

Editorial in Engineering, London, May 28, 1920.

The time was when India possessed some of the finest roads in existence. Today many of them have disappeared and long lengths even of the main trunk roads are impassable —parts have returned to jungle, bridges have been subverted to other services, and in several cases have actually vanished. This astonishing record of enlightened policy on the part of the government of India was the subject of a very intersting paper read by Lord Montagu, of Beaulieu, on Thursday, the 20th inst., at the Royal Society of Arts. As Adviser on Mechanical Transport Services in India the author has had ample opportunity of becoming acquainted with the actual state of affairs. A confirmed advocate of motor vehicles, Lord Montagu might have been expected to express himself in much stronger terms than he actually used. His facts are undeniable and constitute a serious impeachment against the government of India.

It is well known that in India the government is directly interested in the railways. For this reason, it has been argued they have allowed what was once a good system of roads, with certainly first class trunk roads, to be neglected, in order to encourage traffic to the railways. Formerly the roads were essential to the movement of troops—it is now considered that these can be better transported by rail. Provided the line is secured railway transport is certainly much more effective. It was pointed out, however, in the discussion that railways of India are very vulnerable indeed and that in any serious trouble in the country they would be liable to easy interruption. No one who knows anything of India and the ways the railways are worked there will doubt this, and will recall innumerable points where they might be cut, all of which it would be impossible to guard adequately. Yet in spite of this the roads, the only alternative, have been allowed to get into a state of disrepair. In fact, they have proved of so little interest to the government that it is twenty years since the last returns and statistics concerned with them were drawn up.

Distances in India are great, and it would not always be possible to use road transport to supplement the railways, but when it is pointed out that during the Afghan war of 1919 a car of army supplies took three months to get from Karachi to Peshawar, it may almost be asked if road transport could possibly have done worse. This journey was over a single system, and not over a route involving running over various railways, when some delay is often excusable. The operations of 1919 were on a much larger scale than is generally realized, the railways had to handle unprecedented traffic at a time when they were suffering seriously from the effects of the war of the previous years. The road transport available was at the time more than occupied with work beyond railhead. The combination of circumstances was against efficient transport.

A good deal was heard in England of the breakdown of the roads under the motor transport used in this frontier war. It has to be remembered that these roads, many of them without good surfaces to start with, were called upon to withstand very heavy traffic indeed all through the summer. Although repairs were put in hand it was in many cases almost impossible to carry them out as well as desirable. In the first place the repairs had to be executed in the middle of the hot weather, when, up the passes where there is no water, the material cannot be thoroughly consolidated. In the second place the repair material was limited, on account of lack of transport and labor, to what was near at hand. While in places this happened to be fairly good, in others it consisted of a flakey shale, the pieces of which simply slid over each other until powdered to dust. Once the roads had succumbed to the heavy motor traffic it was therefore all but impracticable to renovate them thoroughly during the actual military operations.

Lord Montagu points out the need for lateral roads along the frontier. At present to get from one area to another, a journey has in cases to be made many miles back to a junction point and then out along another radiating road, involving two sides of a very long triangle. Lateral roads with branches up the valleys would greatly facilitate operations. It is to be hoped, of course, that road building in these corners of the earth will tend as it has elsewhere to hasten the march of civilization and order, and that they will become eventually highways for commerce rather than military necessities. We pay annually large sums to these frontier tribes if they behave themselves and do not raid and otherwise make trouble. How much better it would be if the policy were more constructive, and an equal amount of money distributed to the tribes by way of payment for road-making.

It is doubtful whether frontier roads can ever be made dustless, however desirable that may be from the point of view of military operations. The clouds of dust raised by motor transport are, it must be admitted, a veritable danger on the hill roads, while the discomfort to marching troops is enormous, but the idea of tar-spraying would seem almost out of the question though it might be adopted more frequently in cantonment.

The Creative Mind and Socialisation of Industry

Editorial in Engineering, London, May 28, 1920.

Kingsley commenced his delightful, if not wholly trustworthy, lectures on the Roman and the Teuton by a parable in which he likened ancient Rome to a fairy palace or garden situated in a primeval wood. Inside the palace dwelt the Trolls watching their fairy treasures and by their cunning constantly creating fresh wealth. Outside the garden lay another race, poor and quarrelsome, and learning every day more and more of the wonders of the fairy palace. Finally they break in and master the owners, but the fairy wealth has disapeared no man knows where. The conquerors captured all that the vanquished possessed save their cunning, and in this instance the word should retain its primitive meaning of "know how," and without this purely immaterial possession all that remained to the disappointed invaders were a few petty spoils.

For many decades past the proletariat has been fed by our modern materialists on fairy tales as to the immense treasures that are to become theirs by the mere process of seizure, but were the socialisation of industry effected, triumphant democracy would undoubtedly suffer a disillusion as astonishing as that encountered by the tribes which captured Rome. This, indeed, is precisely what has happened in Russia, where the wealth seized by the Bolsheviks disappeared for the most part in the very act. Thus from a comparatively rich and prosperous country that immense empire has been reduced to a state of abject poverty, in which no one save a few officials can attain to more than a most meager subsistence allowance, as his reward for compulsory labor enforced for 12 hours a day.

The creative mind, in short, to which every great increment of wealth can be traced, fits in badly with either a communistic or a co-operative scheme of society. The man of genius is ever and necessarily an individualist.

We need not, however, go so far as Russia for evidence that the value of an undertaking is apt to diminish when its control is transferred from experts to the community, which in practice means to politicians and beaurecrats. In an exceedingly interesting and informing address to the employes of the Allgemeine Elektricitäts Gesellschaft, Mr. Felix Deutsch observes that during the four years before the war the Berlin Electricity Works distributed to the shareholders some 6,129,000 marks annually. The city having a first charge of 10 per cent on the gross profits received from 3,500,000 marks to 4,000,000 marks annually, while in other taxes the company contributed annually to public purposes another 3,000,000 marks. It thus appears that the share of the community in the profits of this undertaking exceeded by one-sixth that of the shareholders, and it should be noted that the public charges were first charges on the undertaking, although the public took none of the risks. Nevertheless the city having got much, desired more; and decided accordingly to acquire the undertaking. The result was an immediate fall in the profits, which continued, and has ultimately led to the complete disappearance of all return to the new owners.

Of course, the conditions have been abnormal during the past few years, and were it not that the experience has been frequently paralleled here and in normal times, it would be unfair to quote it as an example of the futility of socialisation.

Telegraph profits it will be remembered disappeared rapidly after being taken over by the state. Again, some 15 years ago, a large borough in the London area refused to renew a lease of their tramways undertaking to the company then working it, in spite of the very liberal terms offered. The liberality of these terms was, in fact, used as an additional reason in favor of getting rid of the company, as it was argued that the profit on working must be extraordinarily high to have made such proposals possible. The actual result of municipal management was the rapid disappearance of all profit whatsoever. A non-material something had disappeared with the transfer from private to public control, and with it vanished the anticipated large relief to the rates. Of course, had the town in question been situated outside the London area a nominal profit might have been secured (as is done in Manchester, Glasgow and other provincial cities), by denying to the public the advantages of novel and improved methods of transport, but it can hardly be doubted the loss to the public in those cities, thus occasioned, far exceeds in value the relief to the rates secured by this short-sighted policy. When, as in the London area, it is impracticable to establish a legal moncpoly of transport, the cry of the social reformer is for what that self-constituted authority on the principles of mechanics and on transportation, the late Sir Lawrence Gomme, called the "organization of the traffic." This put into plain language means that when the railways were first introduced the traffic should have been so organized as to keep the stage coaches permanently in service.

While, as repeated experience has shown, the socialisation of an industry retards or inhibits the creation of wealth, it may be observed that under our present system of industrial organization the proportion of the total profits taken by those who provide the ways and means is but a small fraction of that secured by the operatives employed. Some interesting figures on this head were afforded by the census of production taken in 1906. From the returns there made it appears that in the engineering trades the capital investments averaged some £180 to £200 per employe, and the average dividend did not exceed some 4½ per cent to 5 per cent. It is this small percentage that constitutes the fairy wealth that the proletariat is urged to seize, and which, if it attempts to take, will disappear in the process. It amounts in all to some £9 to £10 per head, and this figure is singularly confirmed by corresponding figures for eGrmany given by Mr. Deutsch. He states that the average return before the war on the capital of industrial concerns quoted on the Berlin Stock Exchange did not exceed 6 per cent, although only thoroughly sound concerns were admitted to quotation. Some 66 companies with, in the aggregate, 783,781 employes, paid over 10 per cent, and, Mr. Deutsch has been able to secure full data as to the distribution of the profits made by these exceptionally profitable undertakings. Of this total, salaries and wages took 76.7 per cent; rates and taxes, 11.7 per cent; and the shareholders, 11.6 per cent. If the whole of the proportion taken by the latter were distributed among the employes the amount received would have been about 250 marks per head, or about £12 10s. ($60).

In view of the exceptional prosperity of these companies this figure is in good agreement with that derived from a study of the British census returns. If, however, we reduce it in the proportion of 6 to 13, that is to say, in the proportion of the average dividend to the exceptional dividends paid by these particular companies, the maximum possible gain would amount to no more than some £6 ($29) per head per annum, a margin which would rapidly disappear when the control of experts was replaced by that of a committee of politicians.

Of course, as Mr. Deutsch points out, the amounts received by the shareholders is the residue available for distribution, and does not include the sums carried to reserve. These reserves are essential to the continued prosperity and extension of a business, and when reinvested in it yield a return of which labor takes over three-fourths, the state and municipalities at least an eighth, while from 1 per cent to 3 per cent should be expended in research, so that the final benefit accruing to the shareholder is far from extravagant. The accumulation and expenditure of reserves on the extension of a business is essential to its continued growth and prosperity, and from this point of view there is much to be said in favor of the plan of taxing (in normal times) only the sums distributed as dividends, since in the ultimate the nation profits far more by the extension and development of a business than it does by sweeping into the exchequer part of the undivided profits. Ploughed into the business the latter will produce new dividends from which the nation will take its toll and at the same time employment will be found for additional officials and workmen, each of whom will also contribute to the revenue by direct or indirect taxation.

A Few Plain Words on Government Ownership

Editorial in The Engineer, London, March 12, 1920.

Age has not robbed Mr. Frederic Harrison's thought of its energy nor his pen of its incisiveness. For real trenchant truths for labor we must go far to beat the "appeal"—save the mark!—which, through the medium of the Liberal Anti-Nationalization Committee, he has addressed to British trades unionists. Nationalization! His blows resound upon the ribs of that hollow god. The miners, he exclaims with scathing sarcasm, "go rather slack, naturally, for mine owners; but how furiously they would work for the 'Nation'! Why swagger like this can hardly take in the smallest pit boy." On the subject of the Sankey Report, he tells the unions that they are "being hamboozled by a juggling use of names and phrases. If you want bureaucracy, say so. If you want mines for the miners, speak out. That is plain Bolshevism." But it is when Mr. Harrison comes to direct action that his straight left—or would it be more correct in this connection to say his "hook to the jaw" is used with most "deadly effect." "When we come to what is called 'Direct Action,' that is terrorism—to pass from rotten economics to a dastardly crime—you who are about one-tenth of the nation in voting power want to put more money in your pockets, and think an Act of Parliament of your own making will do it for you. So, if twenty millions of free electors do not accept your bill, you intend to strangle mines, rails, docks, so that infants may die, business may be suspended, wages stopped all round—and general 'hell given them.' Given to whom? Why, to yourselves and your own kin!" "You know very well," he continues, "—or rather your leaders know, but they hide the truth—that you are now living on doles—i. e., on charity. Your labor does not produce the value of what you receive in payment. Most of your living is paid for by others. . . . You are being maintained by a gigantic system of outdoor labor relief! And yet you want to plunge into a huge eight thousand million deal—the cost of compensation to capitalists—and throw trade into a gambling chaos." It is good now and again to give blunt facts in a blunt way; to quit arguing philosophically, to "drop the items and give the tot," to fire off conclusions and omit the stages of reasoning by which they have been reached. Fabians, highbrows and intellectuals may deplore the unseemly directness of Mr. Harrison, they may deprecate the violence of his methods, and remind him that whatever may be permitted to other ladies, the prejudices of Mrs. Grundy must be observed where Truth is concerned and her appearance in her conventional attire cannot be tolerated. But other people who do not care to smother common sense in a "smoke of words" will rejoice that someone has been found to tell labor the truth in the fewest possible syllables, and to express the general sentiment with an energy and directness that few others can and none dare command.

Salary of an English Municipal Engineer

Editorial in The Surveyor, London, June 4.

After all that has been said and done during the past year with regard to standard scales of salary for municipal engineers, it is a little disquieting to find a Norfolk rural district council, comprising 37 parishes with about 220 miles of roads, offering for the appointment of surveyor of highways such a salary (particularly in these days) as £180 ($900) per annum. According to the latest scale of civil service bonus this is equivalent to a pre-war figure of rather less than £80 ($400) a year—an aspect of the matter which can hardly have been present to the mind of the council when fixing the rate. Again, on the basis of a six-day week, the proposed rate is about elevent shillings and six pence ($2.75) a day, as compared with the dock laborer's sixteen shillings ($3.84). The miner or railway servant is a veritable Crœsus by comparison! But, it may be said, the annual sum of £50 is to be added to cover traveling and certain other expenses. With the present cost of travel, however, this sum is probably inadequate and certainly not excessive. The only thing to be said for the terms offered is that their very frankness is likely to deter from applying all except that limited number of individuals who are content to look upon labor as its own reward. For our part, however, we prefer to remember that the laborer is worthy of his hire.

The Future of Railway Track in Great Britain

Editorial in The Railway Engineer, London, March, 1920.

It is a matter of common knowledge that the type of railway track in general use in Great Britain differs radically from that almost exclusively employed in every other country in the world. With the exception of the western section of the State Railways of France, the Great Indian Peninsula and certain other lines in India, and minor railways elsewhere, in the British Isles alone is to be found the bull-head section of rail, which requires a cast iron chair interposed between itself and the sleeper for its support. In all other countries the flat-bottomed or Vignoles section, which combines a wearing head with a flat foot to rest on the sleepers, holds practically undisputed sway. In this connection it is interesting to trace briefly the history of the various sections which have developed into those now in common use.

The earliest rails were probably the cast iron "edge" rails introduced by Jessop of Butterley, in 1789. Rolled rails of wrought iron were first used in 1805, and consisted of plain bars of square section, spiked directly to stone blocks; this type of rail developed subsequently into the T-section, of which the upper portion was used to sustain the wear, and the lower or vertical portion of the T rested in cast iron chairs. Rails of this pattern were used in laying the Stockton & Darlington, Liverpool & Manchester, and other contemporary railways of the 1820-1830 period. It was in 1836 that Charles Vignoles introduced his rail of the inverted T or flat-bottomed section, but it failed to find acceptance in this country. Probably the difficulty of rolling the flat base of these rails satisfactorily in the early days of rail manufacture had much to do with the lack of support accorded to them by British rail users. From the T-section rail developed an early form of "parallel" rail rolled for the Bodmin & Wadebridge Ry. in 1834; this had a lower flange smaller than the head, and may be looked upon as a direct precursor of the present bull-head rail. But before the bull-head rail came into common use another section was designed, and, for a period, almost exclusively employed in this country.

This was the "double-head" rail, introduced by William Locke when building the Birmingham & Warrington section of the present London & North-Western Railway in 1835. The double-head rail was of symmetrical profile, with a head and foot of equal sectional area, designed so that, after one flange had been partially worn down under traffic, the rail might be reversed in the chairs and the wear on both flanges equalized. Had a practice been made of turning the rails fairly frequently the object of the design might have been realized, but with the gradual increase in the volume of traffic and the weight of the rolling stock the rails were often found to be so chair-marked on the underside, or indented with the pressure of the chairs, as to be unfit for running over when turned. Another defect was that of "hammer-hardening" or loss of strength in the upper table of the rail, which frequently exceeded the loss due to ordinary wear and tear of the surface. Thus the present bull-head type of rail was evolved. In this, while the lower flange is of sufficient strength to form a solid support for the moving load, and to distribute its weight through the chairs to the sleepers, the upper flange has a larger cross-sectional area in order to sustain an increased amount of wear before the rail requires renewal. The strong character and the enduring qualities of the track so laid appear to have prejudiced the mind of the British railway engineer permanently in favor of this type of permanent way.

But the introduction of the steel in place of the iron rail in 1857 largely revolutionized the permanent way problem. Coupled with the various improvements which by that date had been effected in the processes of rolling it rendered possible the rolling of a far more satisfactory flat-bottomed rail than previously. In countries where railways were at that time in little more than the pioneer stage the cost of transporting large quantities of heavy cast iron chairs to the site of railway construction, in addition to the rails, was more or less prohibitive, and thus it was that the flat-bottomed rail, which merely required spiking to sleepers, sprang into general favor. It had clearly an advantage in the matter of cost over the track laid with bull-head rails. But is time went on it was found there were great disadvantages in attaching the rails direct to the sleepers. Owing to the limited bearing area afforded by the foot of the rail, as compared with the base of a chair, in addition to the "sawing" action of rail-creep, the destructive action of the rails on the sleepers increased rapidly in proportion to increases in traffic and in the weight of rolling stock. Ultimately, therefore, users of the flat-bottomed rail found it necessary to interpose between rail and sleeper something to serve much the same purpose as the chair under the bull-head rail, i. e., to distribute the weight coming on the rail over a larger area of the sleeper than was covered by the rail-foot. Thus has come into being the sole-plate, which gives the flat-bottomed rail the same tilt as the chair gives to the bull-head rail (an inclination at right angles to the coning of the tires of the vehicles) while serving also the purpose mentioned above.

The net result is, therefore, that, weight for weight of section, there is very little difference between the prime costs of the two types of track when laid in main lines. In laying a bull-head road allowance must be made for rails, chairs and fastenings; the flat-bottomed road consists of rails, sole-plates and fastening. Actually the cost of the latter is slightly less, but on the other hand the scrap value of the former, on the conclusion of its useful life, is somewhat higher. Further, for the same weight of section per yard there is generally a slightly larger cross-sectional area in the head, and therefore a little more capacity for wear in the case of the bull-head rail. Taking into consideration first cost of materials, cost of laying, cost of maintenance, effective life, and scrap value of materials, it would be very difficult to decide which of the two types of track shows the greater ultimate economy; but in this connection there is a great lack of published data. It will be a matter of considerable interest in the immediate future to see if the return to British railway service of those who during the war have had considerable experience of flat-bottomed track in the war zone has any effect on future British track designs.

A recent event of some importance has been the reversion of an important Indian railway to the double-head type of railway rail. This is to be used in conjunction with a new design of "pot" sleeper, i. e., the large cast-iron inverted bowl so largely used in India, which serves as chair and sleeper combined, the two "pots" being kept at their correct gauge distance from each other by means of wrought iron or steel tie-rods. In the new sleeper suitably designed jaws grip the rails may be turned at will and worn on the head and the foot supporting under the foot. Consequently all risk of chair-marking on the underside of the rail is eliminated, and the rails may be turned at will and worn on the head and the foot alternately until the are worn down to the utmost limit. Railway conditions of the future will require the utmost economy in every department of operation and maintenance, and in view of the enormous amounts of money spent annually in track maintenance there would seem to be a need for closer investigation as to which of these three types of track is ultimately the most economical.

American and English Methods of Sewer Construction

Editorial in The Surveyor, London, April 16, 1920.

One reads about the construction of sewers in America, and one marvels. Are our methods completely out of date, or are the Americans in the habit of constructing works in a costly and dangerous manner? Experience of recent American practice does not justify the conclusion that the work is faulty, or that the method whereby rapidity of construction is obtained is extravagant. There is very little doubt that in this country engineers are too apt to act on precedent, and to leave to the contractor and the contractor's foreman a great deal of work which could be done much better by the engineer. The contractor is very often a person whose knowledge and experience are much less than his commercial ability and assurance; it is more than probable that he relies almost entirely upon his foreman. In any case his business is not, as a rule, limited to one job. At the best his attention must be divided. Thus, the details upon which the speed or economy of the work depend are left to the judgment of the foreman. The average foreman cannot compare in intelligence or knowledge with the properly qualified engineer. We, as engineers, look at his work, and we think that we could see ways of speeding things up or of saving money; but, as a rule, we do not interfere with time-honored methods hallowed by precedent. Therefore the work takes much longer to execute, the timbering of trenches has to be of a character to stand for months, the cost of pumping becomes excessive, and many other troubles incidental to delay occur.

A study of American methods as illustrated by work recently carried out at Granite City, Ill., shows an enormous difference between English and American practice. The work at Granite City may be open to criticism, but it is nevertheless worthy of consideration, as it is typical of much other work. We read of a concrete sewer, 8 ft. in diameter, being constructed on a bad foundation consisting of quicksand in some places, at the rate of 35 ft. in 24 hours, including excavation and refilling. The depth of the trench ranged from 15 ft. to 22 ft. How many of us have seen a trench 15 ft. deep containing a 12-in. sewer left open for months owing to our slow methods! Surely the difference is remarkable. We read of heavy pumping in the Illinois trench. Excavation and refilling were done by means of a grab bucket and moving crane. In good ground only the lower part of the trench was timbered. Planks, 2 in. by 12 in., driven by hand assisted by water jets were used. The joints below the water line were covered with batten strips 1 in. by 6 in. in size. An electrical pump kept the trench water low. The bottom of the trench was leveled by men with shovels, and the concrete base of the sewer was dumped without waiting for the trench to be entirely dry. Collapsible steel forms were fixed, and concrete was dumped from a traveling car fed from a mixer alongside. The work was done in 35-ft. lengths, and the forms were withdrawn after the concrete had been laid 12 hours. Whatever may be our view of such methods, it is certain that an enormous amount of pumping, timbering and troubles incidental to a lengthy process must have been avoided.

Whether our methods will ever be speeded up on American lines or not, it is certain that such speeding up can only be done by engineers. Undoubtedly a material improvement could be effected if engineers of suitable experience accepted the responsibilities usually taken up by foremen of inferior knowledge. If engineers did their legitimate work, it is obvious that they would take up much that is done by workmen who, for lack of knowledge, carry out their work by slow and timorous methods. We should not then be faced with the fact that, while many good engineers are out of a job, there is a demand for foremen, who are offered pay equal to that of an engineer. Why do we allow the ignorant so-called practical man to do our work, and leave us unemployed, while the work suffers?

Simplification of Design of Concrete Structures

From Concrete and Constructional Engineering, London.

In his inaugural address as president of the Society of Engineers, delivered at a meeting of that body, Mr. Bernard Geen remarked that one of the problems facing the engineer of the future would be to practice rigid economy in the use of all materials of every kind which in the past it had been his function to employ. This would necessitate change of ideas in connection with the design of structures. The most pressing needs probably for many years to come would be supplies of iron, steel and coal. For this reason it might be anticipated that the employment of reinforced concrete would very largely supersede the employment of steel constructional work, owing to the fact that the former would permit the use of far smaller quantities of steel and the employment of larger quantities of material of which abundant supplies existed, or could easily be obtained. On the other hands, it must be remembered that there would be of necessity for some time to come a great shortage of timber and it would therefore be necessary to conserve this most carefully. The development of a comprehensive system of unit construction might therefore be anticipated. In a great deal of modern design unnecessary complication was introduced. This was open to grave objection under the most favorable circumstances, and would require greater attention in the future. The objection to it in steel construction was bad enough, but in reinforced concrete construction it was a very serious one. Other things being equal, the design considered best by competent judges should be the one most simple, most direct, most readily inspected and fixed, judged on the same standard of efficiency.

Design of Inlets and Outlets for a Human Stream

Editorial in The Engineer, London, March 5, 1920.

It was Clerk Maxwell, if our memory serves us, who figured the particles of a gas as demons. It is not a long step from gases to fluids, and a not much longer one from demons to human beings, when the matter in hand is the loading of trains or omnibuses or the rapid movement of crowds. There is, then, we submit, little reason why a body of people in motion should not be regarded scientifically and mathematically just as a body of water or a volume of gas is regarded. It is true the individuals have the power of volition, but it is at a very low value, a long way "below par," when a dense crowd is surging through the gates at a football match or being hurried on and off underground trains by the chartered hustlers. We may, we think, regard the coefficient of volition in such circumstances as negligible, and we may consider the units in the crowd as possessed of no more personality than Maxwell's demons or particles of water. Our drift will now be obvious. If we wish to guide gases or liquids in a given direction with the least loss of power and the least generation of friction and heat, we send them through passages of correct stream-line form. Why not take the same course with human crowds? Why not, instead of as now, directing them through orifices which defy all the tenets of liquid flow, provide properly shaped exits and entrances at our stations, at our theaters, our race courses, show grounds, football fields, etc., etc.? Consider the case of the barriers at a railway platform. A crowd collects outside them waiting for the gates to be opened. As soon as ingress is permitted, the progress of those nearest the passage is interfered with by the sideways pressure of those on the wings, and the crowd passes through the opening with jostling discomfort and inefficiency. On the other side of the barrier, instead of spreading out in easy curves, a turbulence immediately inside the gates is set up, and further impedes the flow. If in the place of these inefficient orifices, passages of correct form, based on human flow, were put up, it is 10 to 1 the crowd would get through more quickly and with less inconvenience. One of the laws of liquid-flow is that in a narrowing passage the velocity increases and the pressure falls. Could anything be more desirable in a crowd? The individuals would pass more rapidly through the barriers, and, instead of getting a final squeeze as they do now, just at the moment when they are searching for their season tickets, they would find the pressure around them decreased. We commend the suggestion to railway managers. Its adoption might be the first step towards the development of a science of crowds.

Control of Research

Editorial in The Engineer, London, March 5, 1920.

The proposal to centralize the control of scientific investigations in India has drawn to Nature two letters, which, coming as they do from eminent scientists, cannot be denied attention. The first is by Professor Soddy. His attitude towards the whole question of the organization of research can best be exhibited by a few quotations. The proposal means, in his view, "effectually killing all initiative, enthusiasm and liberty of action on the part of those actually carrying on the investigations," which is "perfectly in accord with what has happened in this country since, in an evil day, the Government assumed the control of scientific and industrial research. . . . Under such a system there seems every inducement for men of originality and scientific ability to give the service a wide berth. . . . The crying need in India, as everywhere, is for men of high caliber and honest, independent mental outlook, anxious only to secure favorable conditions under which they may be left free to pursue their creative work, and, this being secured, careless of wealth, rank and power, save as the necessary antecedents to the essential conditions." The letter concludes with a brief but scathing comment on the powerlessness of learned societies, and a warning to scientists that "unless they band together and take action, they will see their interests sacrificed to the ambitions and love of power of the few. The second letter is by Dr. A. B. Rendle, of the National History Museum; it takes a similar line. "There may have been," writes Dr. Rendle, "some waste of effort in the past both at home and overseas, owing to insufficient co-operation between men of science working independently, but this is a matter for workers to set right among themselves, and will not be mended by an organization conceived on the lines of a German military system. Further, it is unlikely that the best men will be attracted to work under such deadening conditions." Dr. Rendle recognizes that grants of money by the state for research work are necessary, but he thinks the employment of such grants could be efficiently controlled by carefully selected boards of trustees, the scientific work being left to the unhampered initiative of the scientific staff under a head specially suited to the character of the work. We doubt if any comment on these two letters could add to their force. Both writers, it will be observed, insist on the need that scientific investigators feel for unhampered action, and anyone who has carried out research work of however humble a nature will agree with them. But if the state is going to pay the piper, it will insist on having a voice in the selection of the tune. Absolute independence, however desirable it may be, is only possible when, as does occasionally happen, the researcher is a man of means or is supported by others who place implicit trust in him. That is not the way of states; they may trust men with their reputations, but never with their purses.

Ex-Service Men and the Unions

Editorial in The Engineer, London, March 12, 1920.

It cannot be said that the resistance which many trades unions are making to the training of ex-service men is either incomprehensible or illogical, but it is, nevertheless, very deplorable and very injurious. The unions can never get out of their heads that there is only a certain amount of work to be done in the world, and that if they permit the number of skilled men to increase beyond a certain rate unemployment will follow. It is on this hypothesis that the number of apprentices is settled, and it is, in part at least, responsible for "ca-canny" and for short hours.

We must not forget that instability of employment is the nightmare of the artisan. He lives in almost constant dread of trade depression, and each union endeavors to ward off from itself its effects by adjusting the numbers engaged in the trade at the lowest possible figure. Condemnation of the unions must be tempered by our appreciation of this point of view.

The action of each union is, of course, selfish—but that is a common failing from which there is no escape. "Taken i' the lump, human nature is nought but selfishness." If all trades, as at present, refuse to allow their ranks to be recruited by ex-service men, then unemployment for those men must follow, and though each union may be able to congratulate itself that the men do not belong to it and do not fall as a charge upon its out-of-work benefits, the result in the long run is the same.

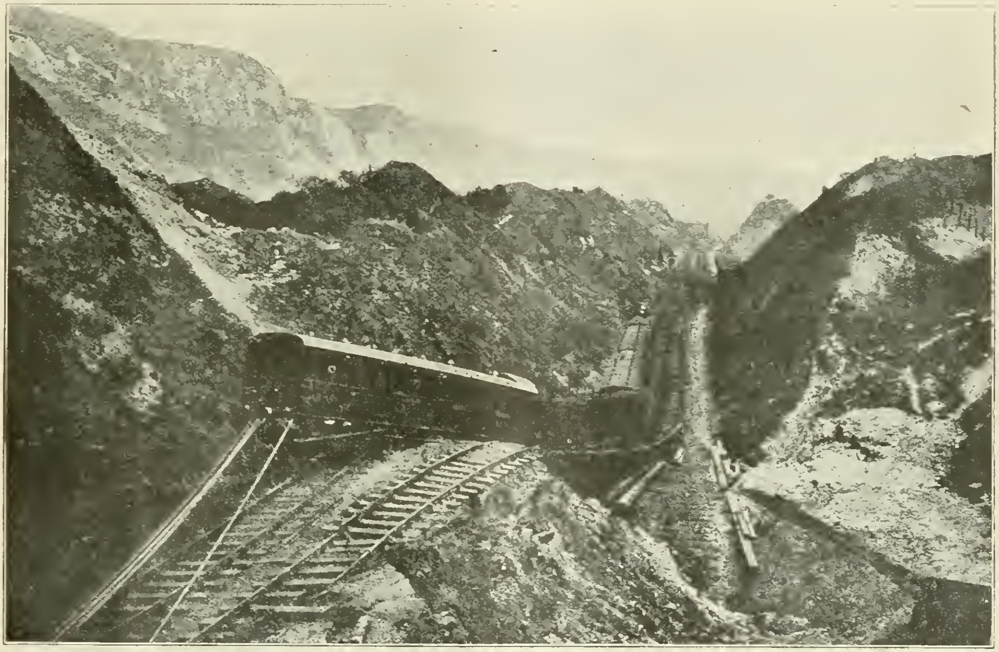
It may be said that the unions could avoid the financial stress to which we have alluded by refusing to accept ex-service men as members, but they are not likely to see the matter in that light, for the plain reason that at some time or another ex-service men may get jobs which would have fallen to unionists. We have put the case for the unions because it is only fair that their attitude should be understood, but at the same time we must deprecate their action, both as inhuman and as uneconomical. It is inhuman because it makes men who served their country suffer a double sacrifice, and it is uneconomical because many trades could now, and will in all probability for some years to come, be able to support many more men than are now engaged in them. Finally, it, in a measure, smacks of just that kind of "tyranny" which labor protests so loudly against. Labor insists that there should be equal opportunity for all, and yet refuses, in a case where one would have thought there are most reasons for concession, to concede to its fellow-workmen the very right which it demands for itself.

Cost of Bad Town Planning.—The Manchester, England, city council on June 2 approved of a town-planning scheme involving an expenditure of $10,000,000. According to The Surveyor it was stated that during the last 20 years the widening and straightening of city streets had cost $5,000,000, an expenditure which would not have been needed if the city had been properly planned originally.

Landslide on English Railway

In connection with a paper on "Engineering Maintenance on Underground Railways" presented last February at a meeting of the British Permanent Way Institution, Mr. A. R. Cooper submitted some interesting photographs of landslides which have taken place along the right of way of English railways. The accompanying illustration, reproduced from the Railway Engineer, London, is a view of the largest slip that has occurred in England.

The slip occurred in 1915 on the South Eastern & Chatham Rl., between Folkestone and Dover, a locality which has experienced several slips during the last half century, though none as large as the one in question. The total length was about 2 miles and the width about ¾ mile. In places the whole of the foreshore moved seawards a distance of 100 to 200 ft., carrying the railway with it. The cause of the slip was the failure of the lower layer of gault under the weight of the high chalk cliffs when the latter were surcharged after heavy rains. At very low tides, as the support on the sea side is largely removed, the tendency to slip is still more pronounced.



Slip Near Folkestone, England, on South Eastern & Chatham Ry. Subsidence at East End of Martello Tunnel.

The illustration shows the slip at the Folkestone end, with a train in the section. A special watchman had been provided as a movement was anticipated, but it came so suddenly that he had not time to prevent the train running into the slip area. He was able to stop the train, and to get out the passengers while the slip was taking place.

"The Man Who Can Invent."—In a recent address Mr. R. O. Herford, works director at the Hans Renolds establishment, Manchester, counseled his hearers—all representative of the administrative side of Sheffield industry—"to look out for the man with a genius for invention, take him off production, where he is worried and ineffective, give him a quiet room and a lathe and let him invent things for you. When there are two or three such men in the works, it is wonderful what results are achieved." Mr. Herford made a point of the fact that if the work of the technical experts was to be applied successfully, all projects should be discussed by conferences attended by the manufacturing, tool-making and inspecting departments, and experimental models should be made for testing purposes.

Effect of Sea Water and Other Influences on Marine Structures

From Engineering, London, April 30, 1920.

The inquiry inaugurated in 1916 by the Council of the Institution of Civil Engineers and approved by the Department of Scientific and Industrial Research into the effect of sea water and other influences on the materials used in construction deserves the earnest attention of all who are responsible for the building and maintenance of docks and harbor works..

The committee, of which Sir William Matthews is the chairman, decided to commence its work by collecting detailed data as to the character of the damage to constructive materials experienced at a number of existing harbor works at home and abroad, and in response to its invitation a large number of valuable reports have been received on the destructive effects of sea water and sea organisms on timber, on the injuries to iron and steel where these materials have been used in structures, and on the deterioration of ordinary and reinforced concrete. The reports also include much detailed information bearing on the general character and scope of the research. These reports, after careful editing and revision, the committee decided to print, either in extenso or in an abridged form, and the result is now before us in the form of an exceedingly valuable and interesting volume.*

Experiences in Use of Creosoted Timber.—The variable success attending the use of creosote can best be shown by a few examples. At Portsmouth, creosote applied under pressure has given satisfactory results. At Colombo, a jetty in which the timber was creosoted with 12 lb. to 14 lb. per cubic foot had to be replaced by a work in concrete. A temporary pier built of creosoted pine at Bangor, County Down, suffered very severely in a few years. The piles, of section 12 in. by 12 in., were completely eaten through at the point where they entered the sand, about the level of low water. At Glasgow, on the other hand, timber impregnated with 8 lb. of creosote oil per cubic foot has been found to be effectually preserved, and piles driven about 58 years ago are still in good condition. At Grimsby, creosote has been found to be of small protective value against limnoria. The experience of Southampton shows that a quay of creosoted pitch pine piles was rendered unsafe in 20 years, and that one or two piles which were uncreosoted had to be renewed after 15 years. Apparently, this observation gives a direct measure of the value of creosote protection, but nothing is said of the manner of application. At Dublin, high temperature creosoting has been found to be the most effective process on account of the large quantity of creosote absorbed, and generally success varies inversely as the hardness of the wood. There is no need to increase the number of examples to show the diversity of results obtained from creosoting, but the conflicting evidence points to the need of further experiment. This is the conclusion of the committee, who propose to test samples of timber of different qualities and characteristics, impregnated with the ordinary creosote of commerce, and also with a creosote into which ingredients have been introduced, that in the opinion of chemical experts may improve its preservative qualities. Samples of timber prepared in this country, in the tropics, and in a colder climate will be used in connection with these experiments. The timbers which appear best adapted to resist the propagation and development of sea organisms are too dense and hard to permit of the penetration in any material degree, of poisonous substances. Effective injection of suitable matter might, however, render softer wood equally serviceable as the harder in resisting the attacks of teredo and limnoria. These tests and experiments will be carried out at Plymouth, where normal conditions may be expected; at Colombo, where tropical conditions prevail and where teredo have proved to be unusually active, and in New Zealand, where intermediate conditions may be anticipated with regard to temperature and marine biology. Experiments at a cold port in Canada will also be considered.

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*First report of the Committee of the Institution of Civil Engineers, appointed to Investigate the Deterioration of Structures of Timber, Metal and Concrete Exposed to the Action of Sea Water. Edited by P. M. Crosthwaite, B. A. I., M. Inst. C. E., Secretary to the Committee, and G. R. Redgrave, Assoc. Inst. C. E. Published by the Committee, Great George street, S. W., and to be purchased from H. M. Stationery Office. (Price, $7.20 net.)

Protection of Timber by "External Paint" and Metal Sheathing.—Other preservatives than creosote have been used with more or less success, as external paint, and in extreme cases, encasing wood in a metal sheathing has been tried. At Table Bay the result of some experiments is to show that the timber best calculated to resist the attacks of teredo, with which the waters are infested, is a soft wood, coated with some preparation of tar or similar substance which will soak into the timber. When paint is applied to hard wood, it forms merely a thin film on the surface and fails to penetrate. This external covering is quickly rubbed off by the action of sand and floating weed, and the teredo effects an easy entrance. The Curbo-teredo process has been practiced at some Colonial stations, but is of comparatively recent introduction. This process consists in coating the wood surface with crude petroleum, and then charring the wood with a blow-lamp to the depth of ½ in. At Sydney, N. S. W., where experiments have been carried on for two years, a qualified approval is given of the method as one "that does not render the timber perfectly immune from the attacks of marine organisms, but charring prolongs the life of the wood very considerably." Testimony of a similar character is furnished from Perth (W. A.).

Metal sheathing can hardly be regarded as a timber preservative since it provides merely a mechanical obstruction to the attacks of the sea borers. In practice, the general method is to cover the timber with tarred felt, over which the metal sheathing is secured. The method is effective if the covering is complete, but great difficulty is experienced in properly covering the joints between the timbers in braced structures. At Fleetwood, Lancashire, a lighthouse was protected by lead sheathing, and this effectually prevented all damage from sea organisms, but in the tropics, where a more active enemy has to be encountered, it is doubtful if lead would prove a suitable material. Muntz metal is preferred as more resistent, and at Brisbane, where a local dense wood, ironbark is used, it is said that the piles protected in this way will last indefinitely or at least up to 40 and 50 years. Concrete covering is sometimes substituted for metal as the material for sheathing and apparently with good effect, but at Portsmouth the plan is said to be "not quite a success." The covering may take the form of "scupper nailing," that is, flat headed iron nails driven into the timber, so nearly touching each other that the space between them may rust over and form practically a continuous rust coating. Here there seems to be a race between the agents of attack and defense.

Durability of Various Kinds of Timbers.—In the present state of our knowledge, notwithstanding the many reports that have been collected under varied climates and conditions of exposure, the committee decided that it is impracticable to tabulate the timbers in any reliable degree according to their durability. An exception is made in the case of greenheart, for which the committee entertain a partiality. This is placed first in the list on account of the resistance offered to the action of sea-organisms, due possibly to the presence of juices, or deterrents, which retard the growth and activities of the sea parasite. This wood is in favor both at home and abroad. Mr. Newell, engineer-in-chief of the Mersey Docks and Harbor Board, insists on the fitness of this wood for construction work in river estuaries in England, by demonstrating the condition of dock gates, erected in 1857, that after a life of 61 years were still in first-class order "and likely to remain so for many years to come." The only protection used was gas tar. At Singapore, greenheart fenders were in serviceable use after eight years, though a highly prized local wood (ballow) would not last more than five years. At Bombay, Demerara greenheart suffered considerable deterioration, especially from pholas, but the penetration was not deep enough to reach the solid heart wood. Simple hardness does not confer immunity. Several correspondents state that oak disappears with annoying celerity. At Hartlepool, elm rapidly disappears, at Southampton both oak and elm suffer severely, and elm had only a life of seven to ten years at Portsmouth. It was found at Sydney that "ironbark," a very hard and close-grained local timber, perished as rapidly as pine.

Australian and Tasmanian timbers, of which the jarrah, karri and blue gum are the best known examples, have been highly recommended, and in home waters they have given satisfaction. At Dover, Southampton, Fleetwood and Yarmouth, blue gum and jarrah have shown few signs of deterioration, and the evidence from Yarmouth is particularly valuable, for the teredo is comparatively active at that port, and the wood has stood for 25 years with but small loss. At Purfleet (Port of London) Mr. Kirkpatrick has had under observation a jetty built entirely of karri. From half-tide level to low level, the timber is perfectly sound; upwards to high water the surface is softened and decayed to the depth of about ¼-in. Above the level the wood is perfectly good and the damage to the middle part, though not explained, is apparently not due to marine organisms. Some trade effluent whose action is obscure may contribute. From tropical countries the reports are less favorable. At Singapore, blue gum piles were eaten through in 18 months. The same fate overtook jarrah piles at Colombo in two years, while 11 months were sufficient to accomplish the destruction of a karri pile 18 in. by 18 in. at Table Bay. The evidence shows that these woods will not endure an exposure for more than a few years in the warm waters of tropical seas. One of the most satisfactory is the wood of the "turpentine tree," syncarpia laurifolia, of New South Wales, which at some stations has had a life of from 12 to 15 years. Many corresponding members have undertaken, at the instance of the committee, to make experiments on the little known woods in use at various ports, not only with regard to the length of life under varying conditions, but also with the view of determining the transverse strength, by breaking small beams between points of support. Possibly new woods will be brought on the market, and certainly much information must be gathered ultimately from the ably conducted researches that will be inaugurated under the scheme, but unfortunately the war has delayed the prosecution of the plan.

Effects of Admixture of Fresh Water with Salt, or of Water Impregnated with Silt and Sewage, in Promoting Decay.—These effects are not directly determinable. Sewage itself is probably deleterious, as shown by the report on Leith Harbor, where it is said a pitch pine pier did efficient duty from 1848-1893. At the latter date, sewage was diverted into the harbor, and deterioration became rapid. Of course the results may be simply coincident in time, but both fresh water and sewage have a very deterrent effect upon the activities of marine pests. Mr. Kirkpatrick informs the committee that no teredo is found above Gravesend, a fact to be explained by the considerable proportion of fresh water in the Thames estuary. The greater evil, in our water at least, is the presence of limnoria and similar wood borers, and the sewage is a distinct aid in ridding our harbors of this plague. The evidence from Dublin in this connection is interesting. Sir John Purser Griffith records that where the water was diluted with sewage the timber remained uninjured, while in the lower harbor, where the water was uncontaminated, destruction was very rapid, until the advent of the oil vessels, when the leakage of oil into the harbor put an end to the activities of the worm. In Belfast, in the older docks, where mud and sewage accumulate, the timber does not suffer from limnoria, but as the newer quays are built nearer to the sea the life of the timber is so reduced that concrete will probably have to be substituted. In the neighborhood of Cork, the quantity of teredo and limnoria varies approximately with the distance from the shore. There is no need to multiply instances, the evidence has amply established the fact that impurities, as well as the movement of sand and shingle, reduces the numbers, and consequently the ravages of the marine borers.

Effect of Sea Water on Concrete Construction.—At present, it may be said with some certainty that the observed defects are entirely due to the corrosion of the steel reinforcement, owing to the penetration of water through the concrete covering. Insufficient amount of concrete easily suggests itself as the cause of the penetration, but this simple explanation does not cover all the observed facts connected with the corrosion of the steel. In the majority of cases corrosion has been noticed to be first observable about the level of high water neap tides. At Southampton, Mr. Wentworth Shields distinctly states that the rust action takes place only above high water level: "Below high water neap tides, where the piles and bracing are kept constantly wetted, they are still quite unaffected, but above that level the piles, bracing and underside of decking have suffered considerably." At Wellington, New Zealand, as again in the Port of London, no serious deterioration was found below high water level. Mr. Cullen, of Brisbane, considers that the action of moist air on the concrete is as effective as that of water. Mr. Kirkpatrick offers an explanation that covers many of the observed facts. He suggests that during the drying of the wet metal, corrosion proceeds rapidly as it is in contact with the air, consequently where the concrete cover is thin and moisture finds its way to the steel in wet weather, one may expect that corrosion will ensue in the periods of fine weather as evaporation continues and cause the concrete to crack. "Below high water moisture will not have time to dry and between the wettings and the steel is protected from those conditions which lead to rapid corrosion."

The signs of deterioration have been well observed, and evidence shows that the first symptom is the appearance of small spots of rust on the face of the concrete. Corrosion next extends in the direction of the reinforcing rods, and cracks can be perceived. Once a crack is started water gains access to the steel, and the effect of corrosion is to force the concrete away from the bars, allowing the entrance of more and more water. No doubt the effects of traffic and the strain of wave action tend to accelerate the opening of the cracks. Mr. Kirkpatrick states that the bursting force of the corroding steel is as high as 4,700 lb. per square inch, and he has had under observation at Gravesend a jetty where many of the beams became cracked throughout the whole of their lengths, exposing the bars. In some cases the whole side of the beam became detached.

Evidently the depth of concrete covering is an important factor in securing permanence of structure. Mr. Cullen at Brisbane is prosecuting a series of experiments to determine the most effective thickness, varying the quantity from ½ in. to 2 in. Meanwhile general opinion favors the view that the minimum thickness should not be less than 1½ in. for piles, beams and similar work, while for decking a slightly less thickness might be permitted. Naturally, the obvious benefits that follow from rendering concrete impervious to water has suggested the desirability of applying a coating of some waterproof material, as tar, or ironite, to the surface of the concrete. Gas tar has been tried, but not very successfully, "perhaps because it was applied too late," says one authority. In the case of an oil wharf constantly saturated with oil no signs of corrosion were apparent. More evidence on the value of waterproofing is needed, as its use has not been general or long continued. No doubt regular repetition would be needed as Mr. Hamer, of Auckland, New Zealand, points out.

It is satisfactory to note that no defects in reinforced concrete are attributed to the concrete itself, and equally interesting that few remarks are made upon the composition and character of the aggregate. The inference to be drawn from this silence is that such matters as the mixing, placing and ramming have become systematized, and that the controlling factors in producing reliable concrete are perfectly understood. The contrast with earlier experience is striking, and the committee directs attention to the misgiving with which the engineering world 30 years ago viewed the employment of ordinary concrete in the construction of dock and harbor works. The defects which undermined confidence owed their origin to porosity in the concrete itself and the infiltration of sea water. Wherever sea water can soak into the concrete and subsequently exude, the magnesium salts in the sea water withdraw a portion of the lime of the cement in the form of calcium salts and leave a deposit of magnesia in its place. An example of this action is reported from Scarborough and other places, but the damage generally is not serious. In very cold climates as at Halifax (N. S.) frost may be the cause of injury. In some concrete-in-mass piers, water penetrated the surface of the concrete at the time of high tide. When the tide goes down, the water in the concrete freezes and expands, and upon thawing again with the rising tide, the surface film of concrete falls off in powder. For such temperature effects, water-proofing is apparently the only remedy. Where high-class work is needed the committee recommends the use of concrete in the form of seasoned blocks, made above tide level, and stacked for two months before being set in position in the permanent work. Further, for sea work, they are decidedly in favor of using Portland, rather than Roman, cement, and the use of lias or hydraulic lime in concrete is disapproved.

Action of Sea Water on Cast Iron, Wrought Iron and Steel.—Allusion has already been made to the gradual displacement of cast-iron by wrought-iron, and this again by steel. The action of sea water upon each of these is different, but the extent of the deterioration, its causes and its prevention, cannot yet be decided with certainty. As a rule it may be said that wrought-iron exhibits signs of decay quicker than cast, and steel quicker than either. Some engineers have expressed the conviction that the finer quality of the material the more rapid is the rate of corrosion and the greater the deterioration. In the outer Thames estuary of the Port of London cast-iron appears to be almost unaffected by the diluted sea-water. Cast-iron piers exist in very good condition at Gravesend after having stood the wear of 73 years' tidal variations. At Holyhead, cast-iron columns erected 50 years since show no signs of severe deterioration, though both there and at Dublin the conversion of the surface of the metal into a soft ferrous oxide has been noticed. From New Zealand and Madras, equally good reports are forthcoming. Wrought-iron at Gravesend exhibits deterioration from electrolytic action at points of attachment to cast-iron. The condition gives rise to no anxiety though considerable erosion exists about high water level. The threads of screw couplings on ties fixed in 1894 are still clean and sharp, but from other places, both at home and abroad, the presence of deep pit holes and other signs of decay are reported. Marine growth and the attachment of shell fish seems to act as a preservation in some cases, but often, when this accidental accretion is removed unsuspected pits are found in the metal.

The references to steel structures of comparative recent erection and a general comparison between the behavior of wrought-iron and steel when employed in structures in temperate, as compared with tropical, climates, though much to be desired, cannot be deduced with confidence from the reports. Madras, however, provides some very precise information showing that a beam originally weighing 1,628 lb. was reduced in weight to 663 lb., after eight years' use. Other beams, similarly situated, show a loss in weight, after the same period of time, from 20 per cent to 59 per cent. At Karachi, an angle steel brace lost 22 per cent by weight through corrosion in thirty years. Here, as in a majority of cases, the corrosion was worst at about half tide level. A curious instance is reported from Auckland, N. Z., where some of the flat bar tension members just above water level, though kept carefully painted, became pitted in circular patches. Though the metal was cleaned bright with a file, no paint or tars could arrest the rapid local corrosion on the bars, although adjacent members remained perfectly sound. This corrosion was attributed to some defect in the chemical composition of the steel.

Further Studies to Be Made by the Committee.—In view of such peculiarities, and in the lack of exact information, the committee have, as we have already stated, arranged for experiments to be made on an extensive scale on different qualities of steel and iron of known composition. Samples have been procured for the rigorous testing of medium carbon steel, mild steel, Galahad non-corrosive steel, nickel steel, Swedish charcoal iron, and of two qualities of cast-iron. The object of the experiments will be to ascertain whether it is possible, by means of certain alloys, to produce a quality of steel, which will resist, more or less completely, the corrosive action of sea water, and whether the use of such steels in juxtaposition with ordinary or less costly steel, will be liable to give rise to electrolytic action. The bars of each description of the material, 80 in number, have been especially manufactured, complete chemical analysis have been made, mechanical tests applied, and arrangements perfected for their exposure in sea water, and in air, with the view of alternating the susceptibility to corrosion of each of the classes. Three complete sets will be exposed at selected stations, the first set to be taken up and examined after five years' exposure, the second after ten, and the third after twenty years' exposure. The periods may, of course, be curtailed if found desirable, after the first or second examination.

The research will also include a biological investigation by competent authorities of the life history of the marine organisms by which so much damage is done to harbor works. Only by an investigation of this kind can really useful information be acquired as to the best means of effectually combatting the destructive work of these organisms. The field of inquiry is a wide one and may be expected to yield results of exceptional interest.

Effect of Stored Coal on Concrete

From Beton und Eisen.

It is quite a mistake to regard coal as an inert material, as when stored in large quantities is undergoes oxidation and other changes which may easily result in spontaneous combustion, and this may cause serious damage to the structure in which the coal is stored.

The precise conditions under which spontaneous combustion occurs are not fully known, but the oxidation of pyrites (sulphide of iron) in the coal appears to be one of the chief causes. Some amount of moisture also appears to be necessary. The sulphide is partially oxidised to sulphate, but free sulphurous acid is also produced, and this may attack the concrete, even though no actual fire is produced. The heat generated by the combination of the acid and the free lime in the concrete assists the general development of heat in the coal, and may thus facilitate the production of a fire.

The density and low thermal conductivity of concrete prevent the escape of any heat formed by the oxidation of the impurities in the coal, and thus add to the risk of spontaneous combustion. In addition to this, concrete does not resist heat and pressure, so that it is liable to crack if spontaneous combustion occurs in the coal. Cracks in the structure are particularly likely to occur if the concrete is made of dolomite, as magnesium salts are readily soluble in the sulphuric acid produced by the oxidation of the pyrites; and as these salts dry they fall to powder, leaving a considerably weaker concrete.

The most difficult kinds of coal to store in large quantities are the light brown coals and lignites, as they are much moister than the harder coals and develop acidity and spontaneous ignition more rapidly. These and all coals which show portions of brassy material should only be stored in high concrete bins when the lower portion of the coal is in large pieces, with ample air-space between each, or when provision can be made for keeping the lower part of the coal quite cool. Where these precautions are not practicable, the inner surface of the concrete should be coated with carbolineum or other material which will prevent the coal and the products of its decomposition from coming into direct contact with it.

No precaution will avail if the concrete has been badly made or if it is too porous. For this reason, structures to be used for coal storage should always be built of tamped concrete and the inner surface should be well grouted so as to give it a dense, smooth finish.

A New Name for the Activated Sludge Process.—Believing that the term activated sludge was not sufficiently expressive of this process of sewage treatment, Municipal Engineering and Sanitary Record, of London, offered $5 for the best suggestion for an alternative title. The title, "Forced Aeration Process," submitted by J. B. Croll, won the prize.

The Nitrogen in Sewage

By DR. G. M'GOWAN,

From The Surveyor, London, May 7, 1920.

In the beginning of 1917 I was asked to write a report on the nitrogen in sewage for the Nitrogen Products Committee, who were then investigating the whole question of the supply of nitrogen compounds, with a view to meeting the abnormal demand occasioned by the war. The report sent in was in the main what follows in this paper, though alterations and additions have since been made. The figures given for the production and consumption of nitrogen compounds in Great Britain are taken from the final report of the Nitrogen Products Committee (1920 Cmd. 482).

The Extent of the Problem.—According to the census of 1911, the population of Great Britain and Ireland was 45,221,615, of which 21,946,495 were males and 23,275,120 were females, and a note from the Superintendent of Statistics, General Register Office, dated April 10, 1917, informed me at that date "children under 15 years of age amounted to 30.7 per cent of the total population of the United Kingdom."

If we take, in round numbers, the population at 45,000,000, with 100 males to 106 females, and assume that the children of 15 and under amount to one-third of the whole, we get:

Adult males	14,560,000
Adult females	15,440,000
Children of 15 years and under	15,000,000
	45,000,000

Further, taking the daily nitrogen in the urine at 16 grm. for a man, 13 grm. for a woman, and, say, 8 grm. for a child, and assuming the nitrogen in the fæces to amount to an average of 2 grm. daily, all round, we obtain, for the whole population:

	Tons.
Nitrogen in urine, per day	545
Nitrogen in fæces, per day	88

During the years 1911-13 the average yearly production in the United Kingdom of nitrogen compounds (in terms of combined nitrogen) was 82,404 tons in addition to which we imported 23,979 tons. Of this total we exported 71,490 tons, retaining in this country for our own needs 34,893 tons. Agriculture absorbed by far the largest part of this—viz., 25,015 tons. Towards the end of the war the consumption of artificial nitrogenous manures of all forms had risen to 60,000 tons of nitrogen, in consequence of the addition of nearly 4,000,000 acres to the land under the plow and to more intensive cultivation. Assuming that the present acreage under tillage is maintained and that nitrogenous manuring on a moderate scale is more generally resorted to, Dr. E. J. Russell estimates that eventually 100,000 tons of combined nitrogen will be required annually for fertilizing purposes alone.

Our total yearly consumption of sulphate of ammonia and nitrate of soda, etc., by agriculture in those years therefore came to about 69—say, 70—tons of combined nitrogen per day. The nitrogen in the human excrement is thus approximately nine times as much as that used in the country's agriculture in the form of artificial nitrogenous manures, on the basis of the pre-war application to the soil.

According to the census of 1911, 60 per cent of the inhabitants of Great Britain, and 25 per cent of those in Ireland live in "towns." It would be difficult to obtain accurate figures at the present time, but it may probably be taken with a fair degree of accuracy that the houses of about half the population are connected or partially connected up to the sewers.

(a) Of the half not connected up to the sewers, the excreta, together with a considerable portion of urine, is either eventually put on the land or might possibly be made available for this; under present conditions most of the nitrogen must be lost from leaky cesspits (often purposely leaky), and from privies, etc. Much has been written with regard to the best methods of disposing of excreta, etc., from isolated houses and villages. If its transference to the soil of a garden or field is properly and regularly carried out, as described by the late Dr. Vivian Poore in his "Rural Hygiene" (1894), and "The Dwelling-house" (1898), this can be done quite inoffensively and with great benefit to the soil. But the difficulty in practice is to ensure its being properly done. It is unnecessary to discuss here the question of land disposal of excreta and sewage in connection with water supply.

(b) Of the half connected up to the sewers, much—both of urine and excreta—is lost altogether, so far as manurial purposes are concerned. Thus, to give two prominent instances, the London County Council, after clarifying the London sewage by precipitation, discharges the tank liquor into the Thames at Barking and Crossness, and maintains a fleet of sludge steamers for conveying the sludge some 30 or 40 miles out to deep water. Manchester, after sedimenting its sewage in septic tanks, also sends the sludge out to sea; the tank liquor is treated on contact beds, and the effluent from these beds runs into the Manchester Ship Canal. The smaller towns on the coast mostly discharge direct into the sea, with or without preliminary settlement of the sludge; with such settlement the sludge is available for land.

The sewage which thus finds its way to the sea helps to feed fish, and some of its nitrogen comes back to the land in the form of fish manure, sea-weed, etc., but how much it is impossible to say.

Under certain favoring conditions, the discharge of sewage into the water leads to a luxuriant growth of ulva latissima (sea lettuce), besides other weeds—a plant which rapidly absorbs the free ammonia of the diluted sewage. It is relatively rich in nitrogen, the dried plant containing up to 6 per cent. The suggestion of a submarine sewage farm has been brought forward, in which the growth of the ulva might be controlled. Some attempts have also been made to subject the weed to dry distillation, for the production of sulphate of ammonia. It ought perhaps to be added that ulva may give rise to serious nuisance from smell, as in Belfast Lough. When torn adrift by wind and currents and heaped together in quiet spots, the decaying weed generates sulphuretted hydrogen in abundance.

The Nitrogen in Solution in Sewage.—A sewage of average strength contains, per 100,000 parts, approximately 5 parts of ammoniacal nitrogen, 2 to 2½ parts of organic nitrogen, and 30 parts of suspended solids, organic and inorganic together. Up to now the only practicable way of utilizing the nitrogen in solution—i. e., the ammonia—whether partly from crude sewage, settled sewage, tank liquor, or bacterial filter effluent (when the nitrogen will be partly in the form of nitrate), has been by irrigation and filtration on sewage farms, the sludge from the settled sewage or tank liquor being used for manuring another portion of the land for such crops as will not stand much water.

Since the degree to which nitrogen is assimilated by plants depends on the temperature, the soluble nitrogen of a sewage farm can only be utilized, in the main, during the warmer months of the year. In cold and wet weather the nitrates and, to a lesser degree; the ammonia find their way through the drains to the streams. This loss is at present unavoidable. Possibly, in course of time, some cheap reagents may become available for precipitating the ammonia and the nitrate from sewage liquors and effluents, but there seems to be no prospect of this at present. It is true that both ammonia and nitrate can be precipitated from extremely dilute solutions, but at an impracticable cost. Recent advances in bio-chemistry indicate, however, that a larger proportion of the nitrogen of sewage is likely to be recovered for application to the soil as manure than has hitherto been the case.

At a number of places on the Continent a conservation process—the Liernur process—is (or was) in vogue. This involves keeping the "excrementitious" matter (urine, fæces, sink water, etc.), separate from the "non-excrementitious." The former is treated with 1 to 2 per cent of sulphuric acid and the resulting syrup either distilled with lime for sulphate of ammonia, dried up with ashes, or further reduced by heat to a dry powder and sold as manure. It was at one time proposed to set up an installation at a small town in this country, but the project fell through. While the method must conserve much nitrogen, there are manifest objections to it.

Large numbers of small worms and lower forms of animal life are present in the sewage effluents from bacterial filters and from land, which must help to feed fish in the streams. At the Berlin sewage farm there is a lake which receives the effluent and which is well stocked with fish. I do not know of any place in this country where sewage effluent is systematically utilized in this way.

When there is sufficient dilution to allow of settled sewage, tank liquor, or filter effluent being discharged into a stream without causing a nuisance, the growth of aquatic vegetation is greatly encouraged; some of these water weeds and algæ are very rich in nitrogen, containing up to about 6.5 per cent (calculated on the dry weed). This growth of weed is of course an essential factor in stream purification. When the weeds decay they give rise to deposits of organic mud in the sluggish reaction, which exerts a de-oxygenating action on the stream; but if the bed of the stream gets scoured out by floods and the mud is thus spread over adjoining meadows, some of the nitrogen of the original sewage is recovered for the land. A word of caution should, however, be added here in respect to the manuring of land with the decayed water weeds and mud obtained by clearing out the bed of the stream. I have seen good grass spoilt—i. e., supplanted by rushes and other useless growths—after receiving a heavy dressing of this nature. The stream debris should not be spread at once, but made into a compost and kept until the seeds which it contains will no longer germinate.

The Insoluble Nitrogen of Sewage.—As already stated, a sewage of average strength contains about 30 parts per 100,000 of suspended solids, of which some two-thirds are volatile on ignition—i. e., are for the most part organic and include the nitrogen compounds. Excepting in those cases where unsettled sewage can safely be discharged into the sea, without danger to human beings or to oyster beds, etc., and the very rare cases where it can be run directly on to land without risk of nuisance, sewage is always subjected to some kind of sedimentation, prior to further treatment with the production of sludge of one type or another—viz., settled sewage sludge, precipitation sludge, or septic tank sludge—and to those may be added now sludge from the new "activated sludge" process of sewage purification.

Taking the percentages of water in the older sludges generally at 90, we obtain the following figures for the production of wet sludge, per million gallons of sewage in dry weather.

(a) Quiescent settlement, without chemicals	12 tons
(b) Continuous flow settlement, without chemicals	11 tons
(c) Quiescent settlement, with chemicals	17 tons
(d) Continuous flow settlement, with chemicals	16 tons
(e) Septic tank	1.5 tons

Or, taking 30 gal. per head per day to represent an average flow of sewage, the daily figures for such sludge (90 per cent water) from a town of 100,000 inhabitants, would be:

(a) 36 tons
(b) 33 tons
(c) 51 tons
(d) 48 tons
(e) 13.5 tons

Utilization of Sewage Sludge.—Sewage sludges are utilized or got rid of in various ways—

(1) By being run or pumped in a semi-liquid condition into shallow trenches dug in a field of good porous soil; after the mud has drained and dried sufficiently, the trench is filled in with its excavated earth. If the ground is suitable and the proportion of added sludge not too great, the soil is naturally improved by this treatment and good crops can be grown on it.

(2) By mixing with lime and pressing out as much of the water as possible in a suitable sludge press. The pressed cake, which contains a considerable excess of free lime and which is highly alkaline, is in this way reduced to a water content of 60 to 50 per cent. It is used to some extent by farmers as a manure, but has not much value, partly because of its not being in a fine state of division and partly, no doubt, because of the fat present in it. Not infrequently the pressed cake is tipped when it cannot be otherwise disposed of—a procedure which is to be deprecated.

(3) By mixing the pressed cake with house refuse or with small coal or coke breeze and burning the mixture; the sludge cake itself has but little calorific value.

(4) By discharging into the sea. This has been already referred to.

(5) By drying and grinding, the product being then sold as manure.

The "Globe" manure, made in Glasgow, and the "A. B. C." manure are instances in point.

(6) By distillation alone with the object of recovering fats and also nitrogen—the latter in the form of sulphate of ammonia. I have not myself seen this process at work.

(7) By acidifying with sulphuric acid and allowing to stand for some time. This has the effect of concentrating the sludge to about 80 per cent of water. The concentrated sludge is then dried, mixed with a continuous stream of sulphuric acid, and fatty acids distilled off; degreased residue is then mixed with phosphate, etc., and sold for manure. This is the Grossmann process, as carried out at the Oldham sewage works.

(8) By the addition of some yeast (the Dixon process) the fermentation also bringing about a concentration of the sludge to 82 per cent of water, approximately. The residue is then dried for manure, the product containing about 2 to 2.5 per cent of nitrogen. So far, this process (which is comparatively recent) is only carried out at Dublin, but I am informed

that it would also have been going at Birmingham, but for the war.

Field and pot culture experiments with various types of sewage sludge (but not including the sludges from the "yeast" or "activated sludge" processes) were carried out at different times at various agricultural experiment stations for the Royal Commission on Sewage Disposal, and most of the results are to be found in the fifth report of the commission, Appendix VIII, and Appendix IV., pp. 79-83. The wet sludge had to be previously dried down to about 20 to 30 per cent of water to facilitate transport. The sludges, as experimented with, contained from 1 to 8 per cent of nitrogen.

The crop results were on the whole disappointing, the nitrogen compounds in the sludges being evidently of a resistant character. If some bacterial or other method could be devised whereby this nitrogen might be rendered more available for plants, great benefit would result.

On the other hand there is no doubt that where the conditions permit of abundant quantities of such sewage sludges being applied to the land—e. g., in the neighborhood of sewage works—large crops can be grown. I can recall to mind an exceptional heavy wheat crop, grown on stiff soil, and Mr. Kershaw reminds me of an equally heavy crop of mangolds on light soil; the ground for wheat had received a very liberal dressing of septic tank sludge, and that for mangolds, settled sewage sludge.

Activated Sludge Process.—The sludge is watery and difficult to settle, but it includes the colloidal matter of the sewage and is much richer in nitrogen than ordinary sewage sludge, containing some 4 to 6 per cent (calculated on the dry product). Pot culture and field plot experiments made with it both in the United States and in this country have given very good results, showing that its nitrogen, or much of it, is in a form readily available for plants.

From the point of view of conservation of nitrogen, this process promises well, at least for domestic sewage. I am not in a position to say whether it costs more or less than the ordinary methods of purifying sewage, nor to give a definite opinion as to its future, which will, of course, depend mainly upon the economic aspect. But the conservation in the sludge of the more readily assimilable nitrogen of the sewage colloids and solids—nitrogen which has hitherto been in great part lost—should prove a marked asset in its favor.

This paper has dealt only with human excreta, but there must also be much nitrogen lost in the excreta of horses, cattle, etc., in towns generally, where horses are used, and in market towns where the sale-yards drain to the sewers.

It may also just be mentioned that certain trades waste liquors—e. g., those from wool-scouring, dairies, glue manufactories, etc., also contain considerable quantities of combined nitrogen.

Conclusions.—(1) Of the nitrogen in human excrement, approximately 6/17ths of the whole are present in the urine and 1 17th in the fæces.

(2) The nitrogen in human excrement amounts in this country to almost nine times the quantity used in the form of sulphate of ammonia and nitrate of soda for agricultural purposes before the war, or to about four times as much as is being used now.

(3) Only a comparatively small portion of it is at present returned to the soil, and that portion consists in the main of the more resistant—i. e., the least useful—nitrogen compounds present.

Among the problems still to be wholly or partially solved may be mentioned:

(1) To make the resistant nitrogen compounds of our present sewage sludges more readily available for plants.

(2) To prevent any loss of nitrogen as from nitrogen gas sewage.

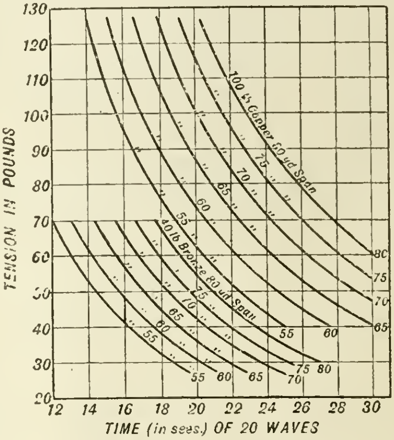
(3) To concentrate the nitrogen of the ammonia of sewage. Since the ammonia constitutes by far the greatest portion of the total nitrogen of sewage, this last is the most important problem awaiting solution.

Moscow Water Supply.—According to the London Times the water supply system of Moscow has broken down under Soviet control, 80 per cent of the houses being without water. Some 1,400 cases of typhus were occurring weekly. The system draws water by a large pumping station on the Moskva River, supplying 150 million litres daily, and 1,315 men are stated to be employed in the works.

Determining the Tension in Telegraph and Telephone Lines

From The Engineer, London, Feb. 20, 1920.

While a considerable amount of data is available to the engineer as a guide to the stresses in overhead lines under different conditions of loading, the application of that information to line construction in practice requires both care and experience. For example, the exact tension to which a line must be set depends on the temperature existing at the time. Care must be exercised in determining that temperature, as the temperatures of the wire and the surrounding air may differ appreciably. Again the wireman adjusts the tension of the line during erection, but it is usually advisable to check his work. The tension and sag of the wire being definitely related, one method is to measure the sag of the line between the poles by marking a distance equal to the correct sag downwards from the insulators on each pole and noting whether the lowest point of the wire falls in the line of vision joining the two marks. An entirely different method consists in determining the natural time of swing of the line considered as a pendulum. The sag varies inversely as the square of the period of oscillation and the relationship is independent of the material of the conductor or length of span. This method has been used with success on heavy power wires with short spans and considerable sag; but according to an article in the Post-Office Electrical Engineers' Journal by Mr. A. C. Timms, the method was of little use on the comparatively small wires used on the main trunk telegraph or telephone lines of the British armies in France. The wires were chiefly 100 lb. copper with some of 150 lb. and 200 lb., and usually the wiremen had a tendency to pull them up too tightly. Mr. Timms describes his method of checking the tension in these lines as follows:



Curves Connecting Tension and Vibration Period.

If a line wire is plucked aside and suddenly let go, or struck a sharp blow near the end of the span, a transverse wave is formed which travels along the span at a speed depending only on the tension and the weight of the wire. If l = length of span in feet, T = tension in pounds, w = weight per foot run of wire, and t = time taken for the wave to traverse the span and return to the starting point, then

$$T = 4\,w\,l^2 \div g\,t^2 \text{ .... } (1)$$

Each time the wave returns and is reflected it can be seen or felt by resting the hand lightly on the wire a few inches from the insulator. To find t it is only necessary to observe the time of 10 or 20 wave reflections, called "waves" in the accompanying diagram, and to measure the span.

Curves have been worked out from formula (1) for copper and bronze wires, so that the tension can be read off on the diagram for various spans, by interpolation. For the same speed of wave the tension in a heavier wire than 100 lb. is proportional to its weight—that is to say, the stress is the same in all copper wires. But it is not the same for bronze as for copper, because the density is different. For longer spans, multiply the tension as shown on the 80-yd. curve by (span ÷ 80)². It is stated that the formula can be relied upon as quite accurate, for perfect reflection occurs at the insultors, provided the wire is bound in or terminated. The accuracy of the result depends only on the measurement of t and the span. With ordinary care and pacing the span both ways one can determine the tension within 5 per cent, which is quite sufficient to decide whether the wires are too tight or too slack.

Action of Sea Water on Concrete

By E. R. MATHEWS,

From The Surveyor, London, April 16, 1920.

Investigations were made by the author to ascertain the relative compressive strength of concrete when—

(a) In air,

(b) Submerged permanently in sea water, as in some maritime works; and

(c) Alternately in air and sea water, as in tidal works.

It usually has been taken for granted that to mix concrete with sea water and to submerge it permanently in sea water has no injurious effects upon the material, but that when it is alternately in and out of sea water, as in tidal works, it has a detrimental effect upon the concrete. The author decided to test this, and for that purpose he had a number of 6-in. cubes made of various aggregate and of different proportions, and, after exposing these in air for seven days, he submerged some of them in the sea, where they were permanently under water, and he placed others in an East Coast harbor, where they were covered by every flood tide, and became dry for several hours during the ebb tide.

(a) The compressive strength of concrete permanently in air has been given in Tests Nos. 1 and 2.

TEST No. 1—3:1½:1 (6 IN. CUBES IN AIR).

Aggregate.	Compressive strength in tons per sq. ft. at the end of One month.	Three months.	Six months.
Granite, ¾ in. to ⅛ in.	346	390	453
Granite dust, passing ⅛ in.			
Cement			
Trent gravel, ¾ in. to ⅛ in.	329	372	452
Trent sand, passing ⅛ in.			
Cement			
Broken bricks, to pass 1½-in. ring	260	308	376
Trent sand, through ⅛ in.			
Cement			

Note.—The figures represent the average of 2 blocks.

TEST No. 2.—4:2:1 (6 IN. CUBES IN AIR).

Aggregate.	Compressive strength in tons per sq. ft. One month.	Three months.	Six months.
Granite, ¾ in. to ⅛ in.	317	364	410
Granite dust, passing ⅛ in.			
Cement			
Trent gravel, ¾ in. to ⅛ in.	290	344	384
Trent sand. passing ⅛ in.			
Cement			
Broken bricks to pass 1½-in. ring	212	242	352
Trent sand, through ⅛ in.			
Cement			

The two results, taken together, appear thus:

Aggregate.	Compressive strength in tons per sq. ft. Six months. 3:1½:1 (4½ to 1).	Six months. 4:2:1 (6 to 1).
Granite and granite dust	453	410
Trent gravel and Trent sand	452	384
Broken bricks and Trent sand	376	352

The specimens for the sea-water test were tested at the end of one, three and six months, and the results are given below.

TEST No. 3 (3:1½:1 MIXTURE). 6-IN. CUBES SUBMERGED IN SEA WATER.

Percentage of water used.	Aggregates as in test No. 1.	Compressive strength in tons per sq. ft. at the end of One month.	Three months.	Six months.
10.2	Granite	276	368	430
	Granite dust			
	Cement			
7.3	Trent gravel	318	350	350
	Sand			
	Cement			
12.5	Broken bricks	224	280	284
	Sand			
	Cement			

3:1½:1.

Aggregate.	In air six months.	in sea water six months.
Granite	453	430
Gravel	452	350
Broken bricks	376	284

It will be seen that when gravel concrete was used (3:1½:1) there was no increase of compressive strength between three months and six months, and practically none in the broken brick cubes, the figures being:

6-IN. CUBES IN SEA WATER. 3:1½:1.

Aggregate.	Compressive strength in tons per sq. ft. At three months.	At six months.
Gravel	350	350
Broken brick	280	284

The author then decided to compare these results (3:1½:1) with a (4:2:1) mixture, and the results of the latter for similar periods to the former were as follows:

TEST No. 4 (4:2:1 MIXTURE). 6-IN. CUBES SUBMERGED IN SEA WATER.

Percentage of water used.	Aggregate.	Compressive strength in tons per sq. ft. One month.	Three months.	Six months.
9.5	Granite	282	316	382
6.9	Gravel	280	276	313
12.0	Brick	186	266	273

It will now be interesting to compare the results of the 4:2:1 concrete in sea water with the 4:2:1 specimens in air.

4:2:1 MIXTURE.

Aggregate.	Compressive strength in tons per sq. ft. In air six months.	In sea water six months.
Granite	410	382
Granite dust		
Cement		
Trent gravel	384	313
Trent sand		
Cement		
Broken bricks	352	273
Sand		
Cement		

It will be observed that the gravel concrete and the brick concrete give poor results.

(c) Concrete Alternatively in Air and Sea Water.—We have seen that concrete submerged in sea water is weaker than when permanently in air. We will now ascertain the effect on concrete of allowing it to be alternately in air and in sea water daily.

The tabulated statement shows the results of the author's tests:

TEST No. 5 (3:1½:1 MIXTURE). 6-IN. CUBES ALTERNATELY IN AIR AND SEA WATER DAILY.

Aggregate.	Compressive strength in tons per sq. ft. One month.	Three months.	Six months.
Granite	248	349	409
Gravel	310	340	408
Broken brick	226	296	329

1. From Test No. 3 we see that concrete mixed with sea water and submerged in sea water has a lower compressive strength than when mixed with fresh water and kept in air.

2 Granite concrete (3:1½:1 and 4:2:1) is less affected by sea water than gravel concrete, the former (3:1½:1) at the end of six months being 453 tons per square foot when in air, and 430 when in sea water; whereas with a gravel aggregate at the end of six months the results were 452 tons per square foot, when in air, and 350 when in sea water.

3. Granite concrete (or sea coast shingle) should be used whenever possible for submerged works, and broken brick should never be used as an aggregate. The results of the broken bricks tests were:

In air (at six months) (3:1½:1) ..... 376 tons per sq. ft.
In sea water (at six months) (3:1½:1) ..... 284 tons per sq. ft.
In a 4:2:1 mixture the results at six months were:
In air ..... 352 tons per sq. ft.
In sea water ..... 273 tons per sq. ft.

(See Test No. 4.)

4. We may take it for granted that concrete formed of any aggregate is of less compressive strength if mixed with sea water and submerged in sea water than when kept in fresh water or in air.

"Air cubes" in every case in these tests gave higher results.

5. Test No. 5 shows us that with a 3:1½:1 mixture, gravel concrete and brick concrete, after being in air and sea water alternately for six months, have a greater compressive strength than if they had been submerged in sea water for the whole period, the relative figures being:

Aggregate.	Compressive strength in tons per sq. ft. In sea water six months.	In air and sea water alternately six months.
Gravel	350	408
Brick	284	329

But they are not as strong as if they had been in air for that period. the six months in air being, for gravel and brick, 452 and 376, respectively compared with 408 and 329.

That concrete submerged permanently in sea water has a lower compressive strength than when in air or when alternately in air and in sea water.

6. For tidal structures where the concrete is alternately in air and in sea water, a gravel concrete is serviceable as well as a granite concrete, but for structures permanently submerged in sea water the latter mixture is preferable.

Arc-welded Building Construction

From The Engineer, London, May 14, 1920.

A few days ago we were invited to inspect a factory building which is being erected at Brixton for Stelfast Wheels, Limited, by the Welded Construction Co., at 14-16 Cockspur St., W. 1. The peculiar interest attaching to the establishment is that it is the first example on a practical scale of the use of this firm's system of arc welding for the erection of the steel work for the roof of a building. The factory, which, when it is completed, will cover an area of 22,000 sq. ft., is arranged with only one floor and has brick walls. It will be covered in with a saw-toothed roof so as to obtain a north light illumination. In all there will be 93 trusses, as illustrated in Fig. 1. Vertical H-shaped steel stanchions are arranged in lines at about 22 ft. centers and they carry 5 in. by 12-in. steel joists. Some of the trusses are fixed immediately over the stanchions, while the others are carried by the joists, being fixed to the lower flanges of the latter midway between the stanchions. Where the walls come, of course, the ends which are not supported by the stanchions or the joists are let into the brickwork.

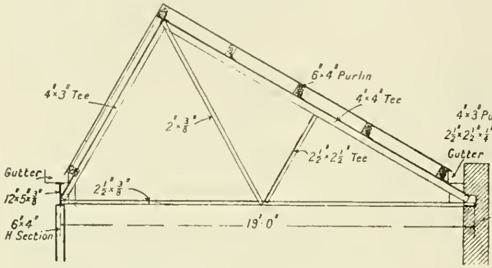


Fig. 1—Arc-Welded Truss for Saw-Tooth Roof.

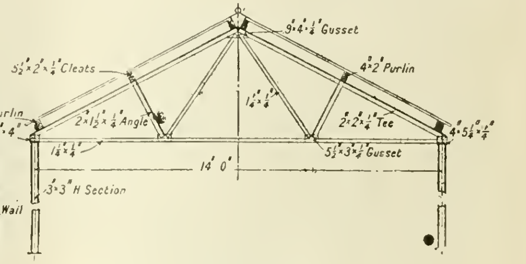


Fig. 2—Arc-Welded Truss for Stable Roof.

The method of procedure employed is, first of all, to weld to the ends of each stanchion a cap and a base-plate. The stanchions are then erected in line on concrete foundations, the concrete being taken up for some distance above the base-plate. When the concrete is firmly set the H joists are hoisted on to the stanchion cap plates, where they are held in position by special clamps, which ensure that they are correctly placed, and then welded. The trusses are welded separately at ground level, and when completed are lifted into position and welded there. In the case of those trusses which come midway between the stanchions, angle iron cleats are used to form the junctions between the trusses and the joists. One cleat is welded to each joist before the joists are hoisted into position, so that it is quite simple to make the trusses assume their correct position and to clamp them there while the welding proceeds. Similar cleats are welded to the ends of the trusses while the latter are being constructed, so that when placed in position there is a cleat on each side of each end of the trusses and all the cleats are welded to the trusses and to the joists, thus making a good strong job.

It is claimed that this method of roof construction is not only quite as strong as if riveting were employed, but that it is quicker and cheaper than is riveting. The cost of welding one truss, taking a welder at 2s. 6d. (60 ct.) per hour, his labor at 1s. 8d. (40 ct.) per hour, electrodes—22 in.—2s. 10d. (68 ct.), and current, 1½ units at 2d. (4 ct.) per unit, 3d. (6 ct.), amounts, so we are informed, to not more than 9s. 4d ($2.24).

The constructional details of the trusses are well shown in the engraving. The various parts which go to make up a complete truss are arranged in a horizontal position in simple but effective jigs made on the site and the various joints are arc-welded on the A.W.P.—Alloy Welding Processes, Limited—system, alternating current being used. Fillet welds are employed for the most part, though in some portions butt welds are required. No scarfing or bevelling is resorted to and no pains are taken specially to clean the parts which are to be welded. When all the necessary joints on one face of a truss are welded the truss itself is turned over so that welding may be continued on the joints on its other face. For the latter operation a jig is not required, since the welds on the other face keep the various parts accurately in position. When completed each joist weighs about 336 lb. We were informed that one welder and one laborer, having the materials cut to length, can assemble and weld complete one truss in an average total time of 1½ hours, and attain an average output of over five complete trusses in one 8-hour day. As a matter of fact, on more than one occasion they have been timed to produce a completely welded truss in 50 minutes. The work of fitting and welding the cap and base-plate to a stanchion can be done in average working in ½ hour. The operation has actually been done in ¼ hour. The welding of the trusses when hoisted into position is also expeditiously performed.

The current employed is, as we have said above, alternating. It comes on to the site at 6,000 volts and is first stepped down to 200 and then again to 70 for the welding circuit, in which a reactance coil is inserted. The electrodes employed are of mild steel, flux coated.

On the same site are being made numerous trusses and supports for stables at Olympia, and we watched them being produced. They are being constructed in accordance with the drawing given in Fig. 2, and when completed each can readily be lifted by one man. They are made in exactly the same manner as are the trusses first described, simple but effective, jigs being employed.

Influence of Time of Contact of Sterilizing Agent on Water Purification

There is one point common to all sterilization processes, and that is the influence of the time of contact of the sterilizing agent with the water. It is of the greatest importance to allow the sterilizing agent sufficient time in which to act. The following figures thus illustrating this point were given by Capt. A. F. F. Geivan in a paper read April 7 before the Institute of Sanitary Engineers. The figures relate to the action of chlorine on raw Thames water:

Dose of chlorine—	Time of contact.	Percentage of samples in which B. Coli was killed (60 experiments in each case).
1 in 1 million	1 hour	32
	5 hours	97
1 in 1½ million	1 hour	13
	5 hours	88
1 in 2 millions	1 hour	1.7
	5 hours	66

In cold weather 24 hours' contact or longer is necessary if a small dose of chlorine is to be effective.

Similar results are obtained in the case of lime. For example, the following figures were obtained with raw Thames water:

Dose of lime in excess of that required to soften the water.	Time of contact.	Remarks.
7 parts per 100,000	1 hour	B. Coli alive in 93% of experiments.
	5 hours	B. Coli dead in 79% of experiments.
	24 hours	B. Coli dead in 98% of experiments.

Psychological Versus "Scientific" Management

By CHARLES S. MYERS.

From Engineering, London, June 4, 1920. Abstract of a paper read April 28 before the Ceramic Society.

Of recent years efforts have been made to introduce from the United States into this country a system of industrial organization known as "Scientific Management." These efforts have not been successful. The British workman is absolutely opposed to Scientific Management, and the cause of this attitude is not hard to find. It has arisen partly because a system which has met with some temporary success in one country has been introduced without modification into another, where the conditions of labor are obviously different. But a more fundamental cause of failure is that Scientific Management as originally advocated cannot be expected to be generally or permanently successful in any civilized land. At a recent meeting of electrical engineers in London, where a paper was read by an enthusiast in praise of Scientific Management, one speaker after another criticized the system adversely on the ground that it did not take sufficiently into account the human aspect of the problem. This criticism, coming from engineers of this country, is important, seeing that the father of the movement, F. W. Taylor, and many of its early advocates, have been engineers. They have not unnaturally tended to concentrate on the machinery of production, and consequently to regard the employee rather as an inanimate mechanism than as a human individual who has instinctive, emotional and intellectual activities of his own, or as little more advanced than an animal.

Difference Between Psychological Management and Scientific Management.—Implicit immediate obedience, with suppression of independent thought and initiative, was the old military ideal; the army machine soon "broke" him who attempted to redress injustice or who sought to introduce progressive methods. If discipline, essential as it is in the world of labor, is to be reduced to this dead level, at which every spark of initiative and of self-expression is smothered, can we be surprised that the worker resists to his utmost that ideal of scientific management in accordance with which (to quote Taylor's words) "the managers assume * * * the burdens of gathering together all the traditional knowledge which in the past has been possessed by the workmen?" Can it be supposed that mechanical obedience, coupled with high wages and diminished effort, afford adequate compensation for the loss of individual craftsmanship? "No worse mistake," says Taylor, "can be made than that of allowing an establishment to be looked upon as a training school, to be used mainly for the education of many of its employees." The author has no hesitation in retorting that no finer ideal, no aim more in consonance with the industrial spirit developing in this and other civilized countries, or more likely to check blind revolutionary tendencies, can be kept in view than "that of allowing an establishment to be looked upon as a training school * * * for the education of * * * its employees." If, as seems certain, the workers' secrets, and indeed all so-called trade secrets, are to be general property, like the scientific discoveries of professional workers, if, as seems inevitable, specialization must ever increase, the boredom of narrow monotonous occupation must be safeguarded by a wider training of the worker, by his wider knowledge of the factory of which he forms so small a unit. If scientific management aims at turning the worker into an obedient machine, psychological management regards him as a human being, and hopes to invest him with as much knowledge and voice in his industrial surroundings as is compatible with most efficient management.

Social Service as Means for Harmonizing Capital and Labor.—Such treatment as that criticized may have some success in a new country like the United States, so long as there is a plentiful supply of labor and a correspondingly rapid stream of immigration. High wages, says Taylor, is what the workmen want most. But does anyone believe merely that high wages are an adequate inducement for vastly increased output, or that high wages without a vastly increased output are not immediately accompanied by increased cost of living so that the worker is not a bit the better off? A higher standard of living is certainly one of the principal ambitions of the working classes, but that is not the sole motive for his unrest, and his lessened output. He is also moved by jealousy, and suspicion towards capital. He envies the luxurious motor cars of the directors and shareholders for whom he works, and the rich furs, the extravagant dresses, the more varied amusements, the better facilities for education, enjoyed by their wives and children. He believes that capital has hitherto taken an excessive share of the profits of his work. He refuses point blank to accept Taylor's dictum that "all employees should bear in mind that each shop exists, first, last and all the time, for the purpose of paying dividends to its owners." Is not this opinion alone sufficient to damn scientific management in the eyes of labor in this country? In the United States, the first patrons of the movement employed it in order to fight trade unionism. In this country we recognize that the errors of trade unionism are to be removed rather by better mutual understanding and education. The old opposing camps of capitalist and worker can only be harmonized under the common ideal of what, for want of a better name, we call social service.

Payments by Task and by Results.—Two of the most important elements of scientific management are the task and the bonus. "Each man in the establishment,' 'says Taylor, "high and low, should daily have a clearly defined task laid out before him. This task should * * * not be easy to accomplish." Regulations are laid down as to tasks being done in standard time, etc. The standard time is the quickest time in which a job can be done by a first-class man. The system of payment is so devised that the less expert or less industrious worker earns so little that he cannot afford to remain on the job. Taylor's ideal is to secure only first-class workers for scientific management, and to exact from them their maximum output. The workers' movements are timed by stop watches, openly if possible, or concealed in a sham note book if secret timing is unavoidable. Single factories in this country cannot hope to engage only first-class workers, as employers' federations and trade unions would equally seek to prevent it. The employers are not going to allow any one factory to monopolize the most capable workers. The more efficient man does not necessarily put forth greater effort than the inefficient to secure his higher and better output. Rightly or wrongly, many trade unions fear that payment by task, or even by results, means the overdriving of the average and the below-average worker, and the entry of a bad spirit of jealousy, rivalry, suspicion into the workshop. Rightly, perhaps, this attitude has been adopted in view of past experience; perhaps wrongly in view of a more harmonious and better organized future. It rests with the trade unions to see that none but sufficiently qualified men are admitted to the full privileges of trade unionism. It rests with them to exclude grossly inefficient workers, just as the General Medical Council and the Incorporated Law Society excludes imperfectly trained doctors and lawyers—namely, by specified subjects and periods of instruction and by examination—thus preventing over-crowding.

Another well recognized cause of trouble which besets the system of payment by results is the fear of rate cutting. A further cause of trouble which prevents each from doing his best is the fear that the weaker comrade will suffer and that with increasing output there will be increasing unemployment. Until guarantees can be offered that the rate, once set, will not be cut so long as the conditions of work remain unchanged, and that a man will not suffer when thrown out of employment through no fault of his own, no system of payment by results can hope to be really satisfactory.

The Field for the Applied Psychologist.—To investigate and to suggest remedies for such fears and suspicions is the sphere of the applied psychologist, not of the engineer or other expert mechanician. The best can no more be got out of a worker who is suffering from mental discomfort than out of a worker who is suffering from bodily discomfort. A specialist trained in the methods and principles of psychology —the science of the mind—and physiology—the science of the living body—is now fast becoming recognized as essential in all large industrial concerns. Those who realize the enormous contribution made by psychology during the war to the treatment of cases of nervous breakdown will readily appreciate the value of psychology in conditions of industrial unrest. Already in the United States the crude blunders made by scientific management at its inception are being repaired by the engagement in various factories and commercial houses of men trained in psychology and physiology. A National Institute of Psychology and Physiology, applied to industry and commerce, is now being established in this country. Its chief objects will be to train those who wish to take up this kind of work, to undertake special problems in any individual factory or firm when so invited, to establish and apply tests by which applicants for work can be selected according to the occupations for which they are mentally or bodily best fitted, to study and determine the most favorable conditions which tend to the mental and bodily health of the workers, and to harmony and co-operation between management and labor. Various trade unions and federations of employers are viewing the establishment of such an institute with favor, because they feel that, conducted by a body of trained scientific men, without profit, by scientific methods, without ulterior motives, they will from each side be able to appeal to it for an absolutely impartial solution of the various problems that confront them. The task of the Institute is great, and is of national importance, and only the promise of five or six thousand pounds a year more is needed for it to start on its career.

Psychological Factor Must Be Taken Into Account.—In the various inquiries initiated by or comprised in scientific management, the psychological factor must be taken into account, unless the inquiry is to be foredoomed to failure. Thus in the case of motion study and time study, the scientific management expert proceeds to divide up the job into a number of small, elementary movements and (quoting Taylor) to "study with a stop watch the time required to make each of these elementary movements, and then select the quickest way of doing each element of the work, and finally to collect into one series the quickest and best movements." It is here assumed that the quickest movements are necessarily the best. But does it necessarily follow that the quickest way of doing a job is the best way of getting the best quality of output or the least amount of spoiled work? Does it necessarily follow that the quickest way of doing a job involves less fatigue for equal output? Secondly, it is proposed to combine together the quickest ways of doing each element of the work, and thus to reach a standard time and a standard method of carrying out the entire job. Each worker is to be trained in this standard method, and his payment is to be calculated on the assumption that the first-class man can be taught thus to perform the standard task according to standard method within standard time. It is assumed that "among the various methods * * * used in each element of each trade, there is always one method * * * which is quicker and better than any of the rest." Certainly there is always one best method of work for every individual, but the best method of work for one person is not necessarily the best for another person. Even two apparently similar engines demand different handling to insure their best output. Are there not a variety (though a limited variety) of equally good first-class styles—as of hand-writing, golfing, violin playing—one or other of which different persons are best fitted to adopt according to their mental and bodily constitution? It is psychologically and physiologically unsound to force a man into one method of work, to train lads in the same mould, on the mistaken assumption that what is best for one is necessarily the best for all. Equally futile is it to take one element out of one man's performance, another element out of a second man's performance, another out of a third man's performance, because they each seem quick and good, and then, by combining them, to expect to reach the quickest and best composite whole. In the living mind and body, the whole is not the mere sum of its parts. It is the function of the psychologist, recognizing the individual differences of equally good workers, to analyze their different methods, to investigate the mental and physical differences corresponding to those different methods, and to see that each worker is trained at the outset in the best method to which he is innately best fitted.

Gilbreth discovered that an expert bricklayer employed quite a different set of movements according as he is working at a fast or at a slow speed. He concluded that a beginner must be taught above all to work at a rapid speed, and to pay little or no attention at first to the quality of his work. To the psychologist this deduction must appear not only unwarranted, but probably untrue. Psychological investigations are clearly needed to determine the relation between speed of movements and quality of output which should be observed during training.

Scientific Management Recommendations Should Be Supplemented by Psychological Considerations — The recommendations and improvements suggested under scientific management require in every direction to be supplemented by psychological and physiological considerations. The human organism cannot be treated as if it were a mere machine, for the human worker is affected by accommodation on the one hand, and by fatigue and boredom on the other. The well-known Monday ill-effect, which has been shown to be independent of alcoholic or other dissipation over the week end, is only an exaggeration of what occurs at the start of every day's work. The operative has first to settle down to his work, to get into his stride, and to neglect external distractions. Towards the close of the morning's or the afternoon's work, the output is again bound to fall off. These variations in working capacity at different periods of the day have recently been shown to occur quite independently of any previous work; that is to say, they are in part due to a daily physiological rhythm—to hourly fluctuations in the daily wave of efficiency.

Where heavy physical work is being carried out, it is insufficient merely to study the most economical movements by which it can be performed. The amount of load which the worker can most efficiently lift, and the amount of time during which he should be under load require investigation. Taylor came to the conclusion "that a first-class man would do his biggest day's work with a shovel load of about 21 lb." In order to keep to a constant load the size of the shovel should vary according to the material to be handled. The total saving effected in the Bethlehem Steel Co.'s works by this and other improved organization, when balanced against the increased cost of tool-room expenses, wages of extra foremen, time-study men, etc., amounted to between 15,000 lb. and 16,000 lb. per annum.

Advantages of Regular Rest Period During Heavy Manual Labor.—Regular rest periods during heavy manual labor are very important, but as regards both load and rest period much investigation is still required, and the numerous pitfalls which beset such inquiries can only be avoided by those already trained in psychological and physiological methods. A regular rest period has a very different effect from a chance pause owing to delay in the arrival of new materials. Its advantages were well illustrated during the war when two trench-digging sections competed against one another for the greatest length of trench that could be dug within a given time. The officer in command of one section allowed him men to dig as hard as they could for as long as they pleased, and then to rest. The officer commanding the rival section divided it into three groups, which he so arranged that two groups were always digging, while there was always a third group which relieved the other two alternately and was always resting. This latter section won easily. The same scheme has been successfully applied to bottle-making, three teams (each consisting of one man and two boys) being allocated to two machines. Their work was so arranged that one team was always resting for 20 minutes, while two teams were working for a 40 minutes' spell. The result was a very considerable increase in daily output.

By arranging materials at a convenient height, alike in brick-laying and in assembling, needless fatigue has been reduced, and output increased enormously.

Efficient lighting has been proved not only to increase output, but to reduce accidents and breakages. Dim twilight and blinding glare are equally objectionable, involving all the well-known consequences (mental and physical) of eye strain and fatigue. Over-crowding not only leads to needless accidents and breakages, but by perpetuating an atmosphere of discomfort, it inevitably induces a frame of mind in which the operatives cannot work their best. The same applies to avoidable dust and heat, and to deficient ventilation.

Applied Psychology and Vocational Guidance and Selection.—Vocational guidance and vocational selection are likely to be among the most valuable contributions of applied psychology to industry and commerce. Their objects are to advise the applicant as to the work for which he is innately best fitted, and to avoid the disastrous effects of "round pegs" being placed in "square holes." Vocational guidance is applicable to the boy or girl on leaving school, and to the worker who is dissatisfied with his occupation and voluntarily asks for examination or advice. Vocational selection is applicable to all new-comers in any industrial or commercial concern. The basis of vocational guidance and selection is that for each person there is one most suitable occupation, and that in every occupation there are some who succeed better than others. Attempts have been and are still being made to determine a person's fitness for different occupations by the shape of his head or face, by the color of his eyes or hair, by the texture of his skin, by the slope of his handwriting, etc. But such methods of procedure are devoid of scientific foundation, and no two people employing them will reach the same results. What psychology does is first to ascertain by careful observation and analysis the mental and bodily qualifications needed for a certain job, next to devise tests which are likely to reveal those qualifications, then to test those tests by applying them to known good or poor workers at that job, and then to select those tests, excellence in the performance of which correlates highly with known efficiency in the job, and to reject tests when such correlation is poor. The tests adopted may be weighed according to their importance, i.e., according to their proved correlation. They are finally applied to subjects requiring vocational guidance or selection. Psychological tests have been successfuly employed by our own Navy and Air Service, and on a huge scale by the United States Army during the war. They have been recently introduced into Columbia University, New York, as an alternative to the entrance examinations, the unsatisfactory nature of which is generally recognized. They have been employed for selecting girls who have the quickest reactions and the best powers of observation in the process of detecting defective bicycle balls; they have been devised for selecting the motor drivers of trams, who can speedily apprehend and act on a suddenly given situation; they have been employed for selecting telephone operators who have acute hearing, clear speech, good memory for figures, quick and accurate reactions to given signals; they have been applied also to assemblers, machinists, clerks, typewriters, etc. They have been used for selecting operatives who are best fitted to undergo a course of intensive training, with the result that their ranking, in accordance with the knowledge afforded by the tests, correlated very poorly with the original estimate of their capacity by the foreman who had been in charge of them, but correlated extremely highly with that foreman's estimate when he had become more intimately acquainted with the men during their subsequent course of instruction.

Scientific management has made a great contribution to the future improved organization of industry and commerce. But without the co-operation and guidance of men trained in the principles of psychology and physiology, the merely mechanical innovations advocated by the engineering or other technical expert are fraught with great danger, and are liable to lead to disastrous results. Scientific management needs to be supervised and controlled by psychological management.

The expert trained in industrial psychology should be valuable as a member of the staff of any large factory or commercial house, not only for motion and time study, the distribution of hours of work and rest, and in selection study, but also as a referee in case of differences of opinion as regards human efficiency, i.e., in regard to rate fixing, systems of payment, and for ascertaining and assuaging or suggesting remedies for the causes of suspicion and discontent.

A Recording Submarine Depth Meter

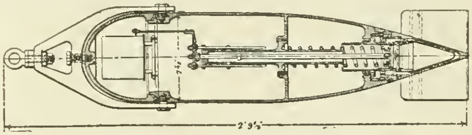
From Engineering, London, March 12, 1920.

Among the many problems connected with the development of mine-sweeping appliances during the war, the accurate measurement ot the depth of towed bodies of various kinds, such as water kites and sweep wires, was of considerable importance. This was especially the case when it was required to devise a form of sweep suitable for "skimming" over a British minefield laid for anti-submarine purposes in order to make it safe for surface craft without interfering with mines laid at a depth very little greater than the maximum draught of vessels likely to pass over the field. It was also imperative to know, in the clearing of deep minefields, that the sweeping appliances were being towed at a depth greater than that of the deepest mines.

The form of sweep in almost universal use by the minesweeping service of this country consists, briefly, of a steel wire rope, towed by two vessels steaming abreast of each other at distance apart of 400 or 500 yd., the length of wire used being about twice the distance between the vessels. The sweep wire is carried down to the requisite depth at each side of the sweep by means of water kites, usually carried on a separate wire, the sweep wire itself passing through a ring attached to the kite. In this way the depth of the sweep can be very readily varied without interfering with the sweep wire.

The depth of the sweep depends on a number of factors, amongst which are the size and length of the sweep wire, the distance apart of the vessels, the speed of sweeping, the amount of "kite-wire" veered, and the type of kite used. It is of primary importance, in all mine-sweeping operations, to know what depth the kite will maintain under specified conditions, the sweep wire being assumed to be at an equal or greater depth. In the case of operations over shallow British minefields, it was also necessary to know the depth of the sweep wire throughout its length. It was for this purpose that the instrument illustrated was designed and made in considerable numbers; it gave excellent results.

The conditions under which the instrument was used prevented the employment of any electrical system giving indications of the depth directly on board the sweeping vessels. It would obviously be impossible to carry electric cables to a number of instruments along the sweep wire without causing considerable disturbance to its normal position. It was necessary, therefore, that each should be self-contained, and record the depth continuously over a sufficient length of time. The construction moreover, should be such as to withstand considerable vibration without interfering with the clearness or accuracy of the record. In order that the attachment of the instrument to any part of the sweep should affect as little as possible the normal conditions, a shape offering small resistence to its passage through the water was required, and a buoyancy only just sufficient to bring it to the surface in the event of the instrument breaking loose from its attachment.



Self-Contained Continuous Recording Depth Meter.

The manner in which these requirements were satisfied will be readily seen from the sectional view annexed. The outer casing of the instrument consists of three aluminum castings, which, when assembled together, have a smooth stream-line profile. The central casting contains the whole of the depth recording mechanism, consisting of a piston working against a spring, whose movement is recorded by means of a pencil on a revolving drum.

The pressure of the sea water is admitted to the piston through holes in the tail fins, direct access of the sea water to the plunger being prevented by the interposition of a thin rubber conical bag filled with a heavy mineral oil. Leakage of this oil past the piston is negligible under the highest pressure.

Access to the recording drum is obtained by simply removing the head, which is held to the body, when in use, by the towing bracket, the joint being made by a rubber ring.

The recording drum is rotated by means of a clock spring acting through a train of wheels, the speed being regulated by means of an air brake so as to give one revolution of the drum in about 1 hour. By this arrangement the continuous rotation of the drum is unaffected by vibration in any direction.

The scale of depth is obtained by direct calibration in still water by means of a sounding line. The maximum depth which can be recorded depends on the strength of spring used, and the instrument has been successfully employed at a depth of 360 ft. Its weight in air is about 30 lb., and in sea water it has a positive buoyancy of from 2 lb. to 3 lb.

Financial Hardships of English Water Companies

Editorial in Water and Water Engineering, London, May 20, 1920.

We have received from more than one quarter intimations respecting the financial straits of water companies due to the heavy increase in the cost of labor and materials. It is pointed out that while the income remains practically at prewar level, the expenditure has increased enormously, with a corresponding fall in profits—if, that is, there is any balance at all upon that side. These increased working expenses are absolutely beyond control, and even if the charges to consumers are increased, under the present statutory provisions the dividends have to be reduced in proportion. We understand that the directors of more than one undertaking are considering the feasibility of reducing working expenses by paying closer attention to the efficiency of pumping plant and similar economies. But the available margin within their control is often very small, and the financial outlook is by no means cheerful.

Removal of Taste from Chlorinated Waters

From a paper by Capt. A. F. Girvan, read April 7, 1920, before the Institution of Sanitary Engineers.

The New River supply of the Metropolitan Water District has been chlorinated by means of chlorinate gas at intervals during the last year or so. The results were quite successful, except in one particular, and that was with regard to taste. It is very difficult to avoid giving the New River water a taste even when it is treated in the same way as the Thames water where no taste trouble caused by chlorination has ever been experienced. No explanation is forthcoming as to the reason for this. Various waters have been examined in the laboratory, and some give tastes very readily, while others are comparatively immune. On the whole, it seems perhaps that the purest waters are the most troublesome, but water from the same source behaves very differently at different times, and its behavior cannot at present be foreseen.

The dose of chlorine is regulated partly according to the bacteriological results in the laboratory, but as these cannot be known for several days after taking the samples they can not serve as an exact guide. It has been found best in this New River treatment to give a relatively high dose of chlorine, followed some hours later—that is, further down the river—by a dose of sulphur dioxide to remove the excess of chlorine which still remains. Until this winter, however, this treatment could be continued only for about two or three weeks before taste troubles began, and then consumers complained, and the treatment had to stop. But this season it has gone on continuously for about nine weeks without any tasting water reaching a consumer. This is the result of numerous experiments by Sir Alexander Houston, who has discovered two ways of avoiding or getting rid of the taste. The first is a very remarkable one. It is simply to increase the dose of chlorine. Suppose half a part of chlorine per million is the desired dose and that a taste develops with this dose, then increasing the chlorine to, say, one part per million will probably give a normal tasting water. Of course, the dose of dechlorinating agent further down the river has also to be increased. In the laboratory the addition of chlorine has actually removed a taste already caused by chlorination.

The second method is a very recently discovered one and is, I think, of very great importance. Little has yet been published on it, but there is a note in the report on the condition of the Metropolitan supply during November, 1919, by the water examiner appointed under the Metropolis Act, 1871, and a fuller description will appear, or may have already appeared, in the annual report of the Society of Chemical Industry for 1919, and will appear in the Water Board reports.

This method is to add a permanganate to the chlorinated water. The waters which have been experimented with up to the present have been chlorinated in such a way as to yield a taste, and then the addition of potassium permanganate or sodium manganate has removed the taste very rapidly. This has been done both in the laboratory and on the large scale, in the latter case about 30,000,000 gal. a day being dealt with. The dose that has been found effective in the case of the New River varies from about 2 lb. to 8 lb. of potassium permanganate per 1,000,000 gal.

It is too early yet to say whether the method will be successful in all cases; but it will be of great use even if it is only sometimes effective. The treatment is certain to be tried all over the world where chlorination is done on the large scale, and if the results are as good as seems likely, the whole community will owe a great debt of gratitude to Sir Alexander Houston for this discovery.

Physical Qualities of Riveted Joints*

From Engineering and Industrial Management, London, April 29, 1920.

There are four methods of failure in riveted joints (1) The rivet may shear; (2) the plate may tear along the line of minimum area of the plate; (3) crushing may take place in front of the rivet, and so destroy the efficiency of the joint; (4) the plate may break in front of the rivet, but this is of little importance in ship work.

One of the results of the research carried out by Dr. Montgomerie is to invalidate the assumptions underlying the theory on which the design of riveted joints rests—that is, the load is not distributed evenly among the rivets, and no uniform state of stress exists anywhere in the joint.

An attempt was then made to obtain some idea of the elastic capacity of the specimens experimented upon.

A series of 12 specimen joints was made by Harland & Wolff, Ltd., Govan. Six treble-riveted joints and six quadruple-riveted joints were designed, the plating and riveting being taken from the rules of Lloyd's Register of Shipping. The treble-riveted joint was effected between plates 23½ in. broad and 0.44 in. thick, and contained 27 rivets ¾ in. in diameter. The quadruple-riveted joints were formed between plates 17 in. in breadth by 0.58 in. thickness, and contained 20 rivets ⅞ in. in diameter. The joints were numbered as set forth below, and instructions were given that no abnormal care was to be exercised in making them, and that the standard of workmanship was to be that obtained in good merchant practice.

Mark.	Type of riveting.	Material of rivets.
A1.	Hydraulically riveted	Iron
A2.	Hydraulically riveted	Steel
B1.	Pneumatically riveted	Iron
B2.	Pneumatically riveted	Steel
C1.	Hand riveted	Iron
C2.	Hand riveted	Steel

The plates were of ordinary steel of shipbuilding quality, and were attached to end forgings by means of steel bolts 1 in. in diameter.

Holders were prepared to carry the strainmeter. These holders or gauge plates were attached to the two plates forming the joint by means of steel set-pins having sharp casehardened points. The strainmeter was set so that the knife edges engaged with the top surface of the gauge plates, and the strain measured was accordingly the total stretch occurring between the points of the set-pins. The taking of the observations thereafter proceeded on the usual conventional lines. Pulls of progressively increasing magnitude were applied to the point. Zero readings were taken by the strainmeter, then a reading corresponding to the pull applied, and finally another zero reading. In order to provide a rough check on the strainmeter reading a pair of micrometer callipers were also employed. Two pins were screwed into the gauge plates and for each reading taken by the strainmeter a corresponding reading was taken by the callipers.

The joints were extended by the large machine at the Glasgow Proving House, which is capable of a maximum pull of 180 tons, and throughout the course of the experiments the usual difficulty was encountered which is inseparable from the association of a delicate measuring apparatus with a machine of this power. In addition to that, the experiments were carried out during working hours, and were subject to disturbance by heavy traffic in the street and in the proving house.

Slip in Treble-Riveted Joints.—The experiments to detect slip were the most satisfactory of the series. The results were as follows:

TREBLE-RIVETED OVERLAP JOINTS—"SLIP."

Joint.	Riveting.	Pull (tons) at which slip occurred.
A1.	Hydraulic, iron rivets	95
A2.	Hydraulic, steel rivets	92
B1.	Pneumatic, iron rivets	92
B2.	Pneumatic, steel rivets	85
C1.	Hand, iron rivets	95
C2.	Hand, steel rivets	105

The results of tests on treble-riveted joints show that the pull producing slip corresponds to a stress related to the rivet area of about 8 tons per square inch, to a stress of about 9 tons per square inch in the unpierced plate, and to a stress of about 11 tons per square inch in the material between a row of frame rivets spaced seven diameters apart. That is, the joint behaves as an elastic solid up to the point at which stresses are produced in the material which the designer would consider from a comparative point of view to be somewhat in excess of those generally accepted as reasonable. The results as produced by the different methods of riveting, and by the different material of the rivets themselves, only vary within small limits. That is, so far as slip is concerned, no effective distinction can be drawn as between the efficiency of iron or steel rivets, or between hydraulic, pneumatic, or hand riveting when properly performed.

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*In order to obtain some reliable information in regard to the physical qualities of riveted joints—when exposed to forces producing stress of normal magnitude—Dr. Jas. Montgomerie carried out a series of experiments at the instance of the Committee of Lloyd's Register of Shipping. He described these experiments in a paper presented to the Institution of Engineers and Shipbuilders in Scotland, upon which the above article is based.

Although a comparatively limited significance was attached to the breaking strength of the joint, it was deemed advisable, if possible, to obtain some data in regard to rupture. The joints were, therefore, afterwards subjected to uniformly increased pulls up to the maximum capacity of the machine, and the results showed that so far as the breaking strength of the joint is concerned no sensible distinction can be drawn between the efficiency of the various joints in respect of the method of riveting employed, or of the material of the rivets used.

Slip in Quadruple-Riveted Joints.—In the experiments to determine slip in the quadruple-riveted joints, the plates lapped together were of approximate dimensions, 17 in. by 0.58 in., and were connected by a lap containing 20 rivets ⅞ in. in diameter.

The pull producing slip corresponds to a stress related to the rivet area of about 7½ tons per square inch, to a stress of about 9 tons per square inch in the unpierced plate, and to a stress of about 11 tons per square inch in the material between a row of frame rivets spaced seven diameters apart.

These results appear to point to the same conclusion as in the case of the treble-riveted joints, namely, that slip occurs at a pull corresponding to a stress in the material which is not lower than that which would be regarded by the designer as satisfactory. The joint, that is, acts as an elastic solid within the limits of working stress permitted by the designer. In the case of joint C2, an attempt was made to ascertain the effect on the pull producing slip by a reduction in the number of rivets in the joint. Five rivets were therefore drilled out of the joint, and the result shows that slip occurred at a total pull of 70 tons. This, expressed in terms of stress referred to the area of the riviets, is 7.8 tons per square inch, which agrees with the results obtained from the other joints. This appears to indicate that the pull producing slip varies directly as the number of rivets in the joint. Before this can be regarded as established, however, one or two further experiments would require to be made.

In regard to the ultimate strength of the quadruple-riveted joints, all were subjected to the maximum pull of the machine. Two of them were actually fractured, and the following table shows the results, together with the information in regard to stress corresponding to these results.

		Stress corresponding to breaking load.			
Joint.	Breaking load (tons).	In solid plate.	Frame rivets seven diameters apart.	Rivets.	(Tons per sq. in.) Material, actual.
A2	170	17.2	21.2	14.1	23.8
B1	178.3	17.9	22.3	14.8	24.8

The other joints, while they did not break, were greatly distorted, and evidently on the point of fracture. The whole of the results on this series confirmed those previously obtained, and point to the conclusion that no sensible difference in ultimate strength exists as between the different methods of riveting and material of rivet used.

Elastic Qualities of Joints.—The results of the above experiment show that a riveted joint behaves as an elastic solid up to stresses in the normal material of a certain amount. An attempt was next made to obtain some information in regard to the elastic qualities of the joint, the amount of stretch that took place, and the distribution of stress over its surface. The difficulties in doing so are obvious; the joint may behave as an elastic solid, but it is a solid of extremely discontinuous form.

Variations are introduced in respect of the rivet holes; the form and tension of the rivets, the shape of the joint, and the effect of bending. It was not expected, therefore, that the results would show any close degree of uniformity.

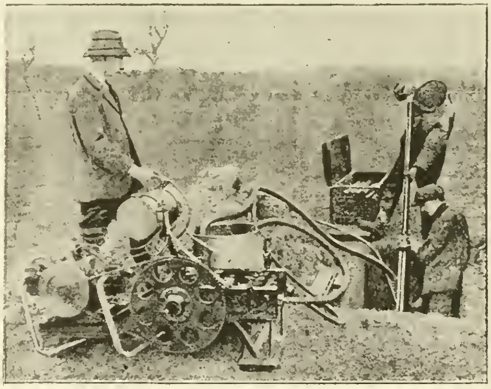
A wide variation of strain (and therefore of stress) was present in the plates.

In carrying out the experiments one or two points were observed which seemed to throw some light on the distribution of load amongst the rivets. It was seen that in the riveted attachment itself the outside rows of rivets seemed to be more severely stressed than the inner rows, and this was clearly seen in the fractured plates, and also in those which were upon the point of rupture. In the opinion of Dr. Montgomerie, this is due to the variation in stress found in the two plates in the vicinity of the outside rows of rivets. The connection between the variation of stress in the joint and the proportion of load carried by the rivets is no doubt exceedingly complicated, but it is certain that the force transmitted is not distributed equally amongst the rivets. Accepting the assumptions underlying the theory of riveted joints a stronger connection can be produced by spacing the rivets more widely in the outer rows than in the inner. This undoubtedly leads to a stronger joint at the point of rupture, but it also implies a more unequal distribution of stress in the plating of the joint in the vicinity of these rows of rivets. In determining the disposition of the rivets in a butt or lapped joint it should be remembered that wide differences in states of stress are encountered at different points, that the rivets do not share equally the burden of transmitting the load, and that the efficiency of the joint when performing the most important part of its work—that is, up to the slip point—appears to depend upon the number of rivets associated with a uniform spacing.

Earth Boring Machine for Pipe Lines

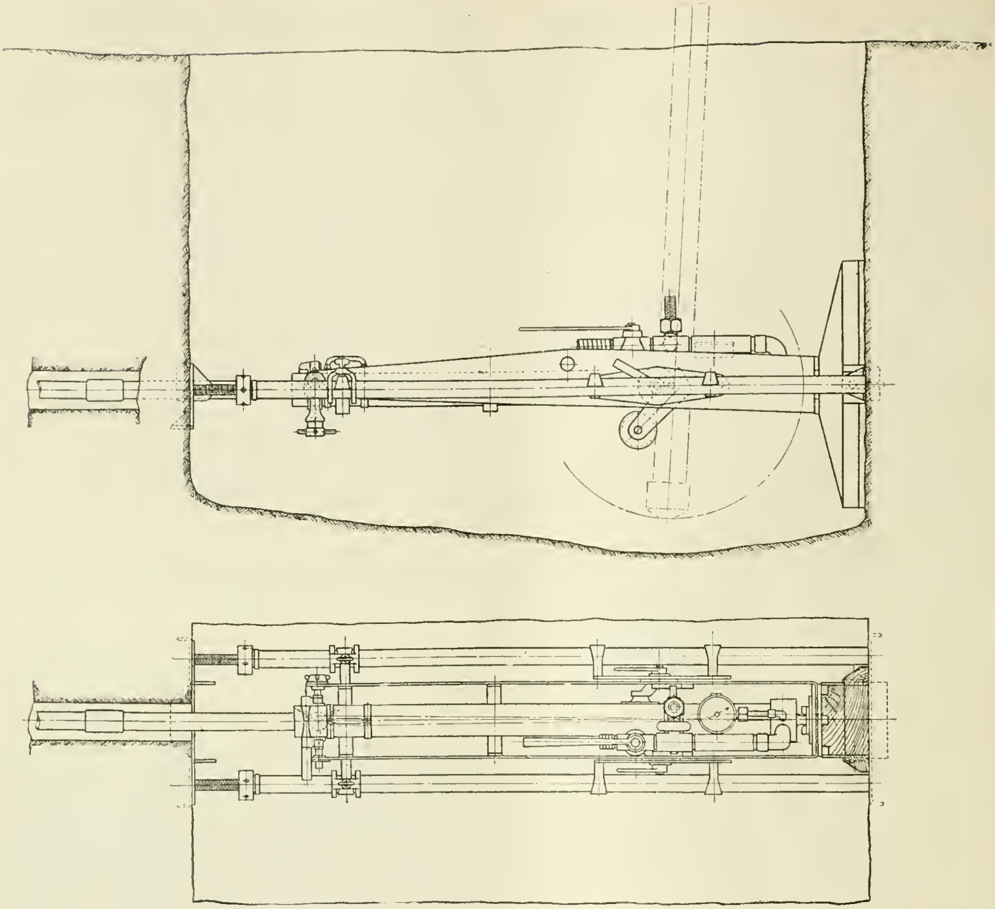
From The Engineer, London, April 9, 1920.

In the following article we describe a machine invented by Capt. A. R. Mangoll and made by the Hydraulic Engineering Co. of Chester, England, which will pierce a hole 4 in. in diameter and 150 ft. long horizontally through a heavy clay in half an hour. The machine is intended for cable laying, pipe laying, drainage and similar work. It operates on the principle of thrusting a stick into clay, and there is, therefore, no spoil. The whole apparatus is portable.



Machine Set Up and Extension Tube Being Inserted.

The machine consists of an hydraulic cylinder of steel tube, carried on trunnions in a light steel frame. The trunnions are near the closed or rearward end, and on them the barrel can be turned from a horizontal to an upright position. Inside the cylinder is a short piston with hinged guiding fingers. The barrel is capable of slight adjustment from the true horizontal by suitable training and elevating gear of a simple order. This "gun" complete on its framework is dropped into a pit dug in the ground to the depth required, a plate at the back of the framework or carriage pressing against a few timbers to distribute the load. The cylinder is connected by flexible pressure pipes to a little three-throw pump driven by a petrol engine. The exhaust water returns to the sump from which the pump draws. The operation of



General Arrangement of Earth Thrust Borer.

thrust boring is begun by turning the gun up to a vertical position and dropping the "pilot" into it. The gun is then turned down and clamped in position, and hydraulic pressure is admitted behind the piston, pressing the pilot horizontally into the soil. The stroke being completed, the admission valve is closed and the exhaust valve opened by one and the same lever—the gun is raised to the vertical and the first extension piece pressed into it. The exhaust water is thus returned to the sump. The three guide fingers referred to keep the base of the extension piece in a central position. The gun is again placed horizontally, and the extension piece is attached to the end of the pilot by a simple pin joint. The pressure is put on again, and the pilot driven forward another 4 ft. Then the same operation is repeated, extension piece after extension piece being added until the pilot breaks through into a pit at the far end—150 ft. away. The pilot is then uncoupled and lifted out of the pit, and the extension pieces are withdrawn and uncoupled one by one. The whole operation of raising the gun, inserting an extension piece, lowering the gun, fixing the pin joint, and thrusting the piece home occupied less than one minute.

The joint is extremely simple and ingenious. The extension pieces are tubes about 2½ in. diameter for a 4-in. hole, with muff couplings at the leading end. Through each coupling is drilled a pair of opposite holes; through the other end of each piece is drilled a corresponding pair of holes, but of smaller diameter. The pins are turned to fit the smaller holes freely, but at each end are reduced in diameter so as to leave a shoulder. The operator brings the holes opposite each other, slips the pin in position, and dabs a little bit of clay round the end. It is found that the clay locks the pins effectively, and that they never fall out. The withdrawal of the extension pieces is easy, since their diameter is a good deal less than that of the hole. The method generally employed is to attach a rope to the last piece and carry it round a pulley. Two or three men on the surface can then pull the whole chain of extension pieces back until the next joint is reached. The operation is repeated until the operator in the pit can pull the rods back without assistance. An alternative method is to turn the gun up to a vertical position, and by means of suitably arranged ropes and pulleys employ it like the cylinder of an hydraulic crane.

The following list of weights will be found of interest:

HYDRAULIC EARTH THRUST-BORER.

	Cwt.	q.	lb.
Total weight of all gear necessary for a 150 ft. thrust boring	13	0	0
Comprising—			
(1) Pump set complete with suction and pressure hose and water tank	4	0	0
(2) Pit base frame complete	0	2	10
(3) Cylinder carriage complete	0	3	12
(4) Cylinder complete with piston valve, pressure gauge and return hose	0	3	17
(5) Pilot	0	2	0
(6) 150 ft. thrust boring tubes complete in timber case	5	3	0
(7) Tool box and spares	0	1	0

Extra—A light trolley weighing 1 cwt. 2 qr. 14 lb. may be used to lift and carry the above details from pit to pit.

The type we saw at work is designed primarily for cable laying, and makes a hole 4 in. in diameter, but larger holes can, of course, be made, even up to 15 in., suitable for the accommodation of water pipes, gas pipes, drain pipes, and so on. The only limitations to the use of the machine is the nature of the ground. It is clearly most suitable for employment in a clay or consolidated loam, and it is remarkable that flints usually met with in such a soil do not cause permanent deviation from the course. Sandy ground with a sufficient percentage of clay can also be satisfactorily thrust-bored.

The overall working speed, start to finish, of a thrust boring 4 in. diameter is 300 ft. per hour. With two men working ahead on the excavation of pits the boring team of three men can thurst-bore two 150-ft. borings complete in an 8-hour working day. This time includes allowance for the extraction of the thrust-boring tubes in each case and cleaning and moving the entire gear from pit to pit.

Development, Detection and Prevention of Algal Troubles in Reservoirs

From a paper by Capt. A. F. Girvan, read April 7, 1920, before the Institution of Sanitary Engineers.

Sir Alexander Houston of the London Metropolitan Water Board has demonstrated the marked beneficial effect of storage as a means of precipitation, but against these advantages of storage we have to set the fact that at certain seasons there may be a development of algæ in the water. In order to guard against trouble of this kind in the case of the London supply, micro-photographs are taken at least once a week. A definite amount of each stored water is centrifugalized, and the sediment which is thrown down is transferred to a cell on a microscopic slide, and a photograph is taken under standard conditions. These photographs examined week by week show not only the sorts of algæ which are present, but also their number, and whether they are increasing or decreasing in quantity.

It has been found that copper sulphate in very small doses is efficacious in preventing or restraining growth of algæ which are the cause of the immediate trouble, others of a different kind may develop still more rapidly, and the final trouble may be worse than the first.

The copper sulphate appears sometimes to upset the balance of Nature and to produce unexpected results. It may, perhaps, be well to add that no copper can be detected in the filtered water by delicate chemical tests.

Up to a few years ago the occurrence of a taste in the water supply was almost the first indication of the presence of algæ in the stored water in undesirable quantity. The reservoirs were then sometimes treated with a dose of copper sulphate of about one part per million. This killed off most of the growth, but the dead organisms continued to pass on to the filters and to choke them rapidly for some time afterwards. The expense of cleaning the beds frequently is very considerable, and the maintenance of an adequate supply of water is rendered difficult owing to the number of beds which may be out of action at the same time. But the study of the photographs enables one to act in advance in various ways. For instance, the engineers in charge of filtration may be warned to have the filter beds cleaned at the first sign of choking, and to arrange that all are in a fresh state, or the reservoir may be dosed with copper sulphate to prevent algal growth reaching a serious amount.

Another method of anticipating filtration troubles is by the "resistance to filtration" test devised by Sir Alexander Houston. It is very simple. A piece of fine linen is tied over the end of a glass tube a few millimeters in diameter; 100 c.c. of raw or stored water is filtered through this and then tap water from a constant level cistern is run through the now partially clogged cloth. The volume of tap water which runs through in a definite time is a measure of the filtering qualities of the raw or stored water. If algæ or other solids are too abundant, the cloth gets clogged and little water passes. The method is more sensitive than the filter beds themselves, so that the engineers can be warned in ample time. This method usefully supplements the photographic one.

It is rare for the stored waters themselves to develop any marked algal taste. Any slight taste is usually removed by a sand filter in good and reasonably fresh condition. The taste appears to become marked only in the filterd water, when there is a thick deposit of algæ on the sand of the filter, and then only under certain abnormal conditions. The removal of this skin, which may be nearly ½ in. thick sometimes, in the usual course of cleaning, will restore the bed to its usual good state of delivering water with no unpleasant taste. If an algal taste has developed in the filtered water, it can be removed almost instantly by the addition of a permanganate.

Causes of Increased Cost of Building in Great Britain

By SIR CHARLES T. RUTHEN,

Senior Vice-President of the Society of Architects.

From The Surveyor, London, May 21, 1920. Abstract of a paper presented at a conference convened by the Society of Architects.

Whatever may be the actual reason or reasons, everyone admits that, whatever calculations may be made as to how many houses should be built in a certain time by the employment of a certain number of men, the output of houses is not, in fact, materializing. A large number of men previously forming part of the ranks of the building industry have removed to other industries and are unlikely to return to their pre-war occupations, and certainly a large number, but not nearly sufficient, are engaged in other necessary and urgent building work. Some, but I do not think nearly so many as are presumed by some people, may be engaged upon unessential and unnecessary building work. The fear, I think remains that house-building work is not proceeding nearly so rapidly as one would wish, and not nearly so rapidly as is necessary for the social security and industrial peace and prosperity of our country.

The reason is stated to be due to the enormous increase in the cost of building, and there is little doubt that this is, in fact, the reason. It is not because there is insufficient money in the country to meet the cost of housing that progress is slow. It is entirely because there is no prospect that, proceeding upon present lines, the country will withstand indefinitely the shock of supplying a very urgent and important national need at a price obviously below the cost of production. Subsidies of all kinds are bad in private and in national life, and only lead to irrevocable disaster. The wages of the workers clearly should be sufficient to purchase the necessaries of life at a price something above the cost of production, otherwise the whole economic structure totters and must inevitably collapse.

Now to what cause or causes must one look for the present high cost of building, and is that present high cost justified? There are a number of reasons that are suggested to one's mind as being responsible for increased cost of building, and they may be set out as follows:

(a) Increased wages payable to the various workers.

(b) Reduced hours of labor, so far as such increase the period of construction and prevent the product of labor from rapidly reaching the consumer.

(c) Increased cost of materials.

(d) Diminution of output of skilled and unskilled labor, of the brain and manual worker.

(e) Profiteering by all sections, including the capitalist, the expert and the workmen, and the resultant exploitation of the dire necessity of the state.

I think that all these causes have contributed to the present high cost of building, and that no single cause can be charged with the entire responsibility. The proper increase in the cost of building work due to increased wages it would be ridiculous to find fault with, and if it is admitted that reduced hours of working necessarily increase the period of execution, which must be so where the volume of labor is strictly limited, then increase in cost of building due to this factor must also be accepted. Increased cost of materials is due in the main to the two primary factors already named, and the discussion of the question of increased wages and reduced hours of labor covers all forms of labor connected with the manufacture of materials or the application of the same to house construction.

Wages and Working Hours.—Now, what proportion of the increased cost of building is due to increased wages and reduced hours of labor, in so far as these factor bear not only upon actual erection, but upon the manufacture of the materials? I fear the effect of reduced hours of labor upon the productive capacity of the workers in the building industry is much greater than is generally appreciated. In pre-war days the working hours per week numbered 54; at the present time these working hours are 47, or a reduction of 13 per cent. That is to say, the capacity of the 650,000 workers in this industry has been reduced to an extent equivalent to the loss of 84,500 workers. In other words, compared with pre-war days, the available workers in reality become 565,500. On May 1st a further reduction to 44 hours per week was to be claimed, making a total reduction as compared with pre-war hours of 10 hours per week, or 18½ per cent. The available workers therefore become, in effect, reduced to 529,750, or a total reduction in capacity as compared with pre-war days of over 120,000 men, as a result of reduced hours of labor.

These figures refer particularly to South Wales, but I think they may apply generally to the whole of England and Wales. The wages of the skilled craftsman in pre-war days, when the hours were 54 per week, were 9d. (18 ct.) per hour, and for laborers 6d. (12 ct.). Today these wages are 1s. 9d. (42 ct.) and 1s. 6d. (36 ct.) per hours respectively. On May 1st it will be demanded that these wages should be increased to 2s. (48 ct.) and 1s. 9d. (42 ct.) per hour respectively. The cost of building work today reaches any figure between 200 per cent and 300 per cent above that ruling in pre-war days. That is to say, a £250 pre-war cottage is priced to-day at from £750 to £1,000, and it would seem that the general tendency is nearer the larger figure and that the prevailing trend is still in the upward direction.

We do not appear to have reached a higher percentage of increase, so far as the wages of those engaged in the building industry are concerned, than 150 per cent upon the average over pre-war wages. In making this statement, I refer to labor required in the erection or assemblage of the materials as apart from the labor involved in manufacture and transport of materials. It would appear, therefore, that there is something unexplained and unaccounted for in the difference between pre-war and post-war building costs in this respect.

The Cost of Materials.—It may be argued that the cost of materials has advanced to a much greater extent than the percentage just named; but it must be remembered that the cost of materials includes the cost of the labor involved in their manufacture and transport generally. Taking the dwelling-house as a unit, there are two distinct parts required for its making—the materials, some prepared, some raw, necessary for its construction and the labor actually necessary for the working or assemblage of the materials. So with the vast bulk of the materials, there are two distinct parts, the unquarried stone, unmined ore, the unhewn timber and unworked clay and so on, and the labor required for their marketable transformation. I therefore suggest that the labor required, whether in the winning of the raw materials, the preparation and transportation of the latter to their ordered arrangement in house form, has not increased throughout more than 150 per cent or thereabouts above pre-war rates.

Again, I say that there is an unexplained and unaccounted difference between pre-war and post-war costs in respect of the labor side of building. I venture to suggest that this difference can only be accounted for by a series of fairly obvious causes, one of which is the diminution of output of the worker, whether that worker be engaged in the manufacture of building material or accessories or in the actual assemblage of the latter in house form. This diminution of output is the reduction of hourly output per man, and must not be confused with the limitation of capacity due to reduced hours of working. The latter is a serious problem, but I venture to suggest not nearly so serious as the former. The continued reduction of the hours of labor has not only increased the burden resting upon the shoulders of the sadly depleted ranks of the building industry, already far from competent to undertake the task demanded of it, but appears to have engendered a spirit of lethargy of a most marked and disastrous character. That feeling of individual responsibility so necessary for the industrial and social security of the nation, and so characteristic of the British worker in pre-war days, appears to have been removed. I feel that not less than 10 per cent of the present increased cost of building is due to this cause, and a further like percentage to the apparent entire absence of administrative control held by the contracting or supervisory authority. The responsibility for this latter cause doubtless does not entirely lie at the door of this much criticized section of the industry, but nevertheless that spirit of "don't care" has insidiously crept in, and the result is unsatisfactory to the highest degree.

When the old pre-war system of contracting with its definite responsibility for the speedy and economic management of contract work came to an end, as is largely the case today, the personal initiative and responsibility by sheer pressure of circumstances also came to an end, and with the disappearance of these attributes the day of economic and expeditious building, of careful organization and management, closed.

Good will and close co-operation of the three sections of the building industry, architects, contractors, manufacturers and merchants and labor, are required if the economical structure of the building industry is to be redesigned and reconstructed. This structure must be monolithic in the sense that the expert must rely upon the organization for a proper finished article, and the management must rely upon the quality of the component parts for the satisfactory execution of the works, and, finally, the labor for the building up of these parts must of necessity take its share in the final and satisfactory completion of the work.

What Is Portland Cement?

From La Revue des Materiaux de Construction.

Scientists who have studied the subject appear to be divided into two groups, one of which declare that Portland cement is merely impure tricalcium silicate, while the other group maintains that it is a highly complex mixture of various silicates and aluminates. Those who regard it as an impure siliciate have clearly overlooked the very considerable proportion of alumina which is always present, and yet to include this would at once destroy their theory. Those who regard cement as a complex mixture have derived their idea chiefly from a study of the behavior on cooling of a number of pure oxides which have previously been heated to complete fusion, whereas Portland cement never reaches this stage, but is only heated to the sintering point. It is also a curious fact that when Portland cement of excellent quality is fused completely in an electric furnace, and is then allowed to cool slowly, it does not possess the special characteristics of cement clinker, but behaves as an entirely different material.

The fact is, there has been far too much guess-work and mere theorizing where there should have been a broad-minded examination of the whole of the known facts. For instance, it has not been definitely determined how far the constituents which first melt during the burning of the cement attack those which are more refractory, and it is assumed, rather than proved, that such attack and fusion proceed progressively. If the most fusible materials melt first, there ought to be visible under the microscope particles of fused material uniformly throughout the mass, whereas a microscopical examination of the smallest particles shows that they are only fused superficially. This superficial fusion may not be due to the presence of more readily fusible particles at all; it may be caused by the low thermal conductivity of the material which allows the exterior of a particle to fuse but does not permit the heat to penetrate into the interior sufficiently to raise the whole particle to fusion point. In fact, the phenomenon of fusion, which appears so simple to the uninitiated, is, in reality, so complex as to be almost impossible of exact observation when studied in connection with such substances as cement and clays. In metallurgy, the microscopical examination of polished and etched specimens often enables the crystalline structure of the metal to be recognized and its various constituents to be identified, but this method fails in the case of Portland cement because it demands a complete fusion of the mass—which does not occur—and the production of normal or nearly normal crystals, whereas in clinker the presence of the impurities and the absence of sufficient fusion prevents the proper formation of a crystalline structure and makes the identification of alite, belite, etc., wholly inconclusive, though these substances are recognizable in completely melted mixture of pure oxides with a composition resembling that of the cement.

Attempts at synthesis by means of pure materials have not led to any conclusive results, as such synthetic mixtures are always "poor" cements, the impurities present in the natural materials playing a far more important part in giving the cement its valuable properties than is commonly supposed. The addition of water to cement provides additional complications without removing any of the other difficulties experienced in endeavoring to ascertain its constitution, for water decomposes the cement, liberating free lime which reacts with the other constituents and sets up a fresh series of reactions. The substitution of other fluids has yet proved whether this substance exists.

It is easy to suppose, with a German contemporary, that cement consists of a single chemical compound, but no one has yet proved whether this substance exists.

Another impossible explanation is worth consideration: if the formation of cement is due to the presence of a catalyst which is included among the impurities, it ought to be possible either to isolate this or to substitute another catalyst for it and so facilitate the production of the cement and make the determination of its constitution much easier. The discovery of such a catalyst might make the production of a pure cement possible.

Influence of Fatigue on Accident Frequency

From Engineering and Industrial Management, London, May 6, 1920. A summary of an article by A. Vautrin, in "Technik and Wirtschaft."

It has been known for some time and experimentally established by Kraeplin that all work done by man, whether physical or mental, is accompanied by a series of reactions which either favor its continuation or oppose it. The most important of the reactions opposing the tendency to continue working is known as fatigue, and may be of a physical or mental character or a combination of the two.

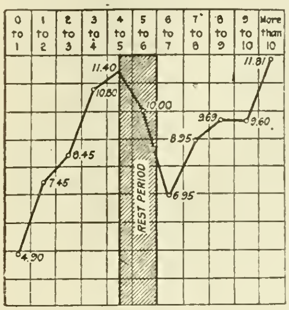


Fig. 1—Distribution of Accidents in the Chemical Industry During the Working Day in the Years 1897-1907 (Hours Worked and Percentage of Employees Injured During Each Hour).

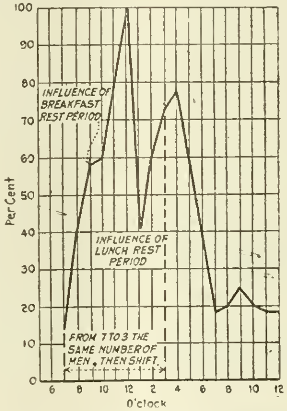


Fig. 2—Distribution of Accidents in a German Cable Factory Throughout the Working Day.

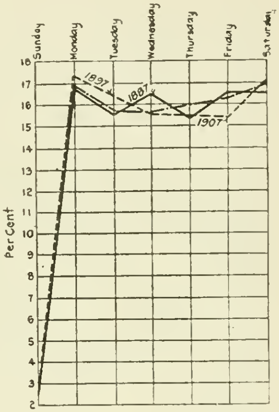


Fig. 3—Frequency of Accidents on the Various Days of the Week, Comuuted as Per 100 Injured or Killed Persons.

As regards its physical nature, it appears that all work produces in the body substances (chemical or organic) which exert gradually a narcotic effect on the central organs of the nervous system. In fact, Weichhardt claims to have found present in animals a poison produced by fatigue which he calls kenotoxin.

Fatigue may be either physical or mental. In physical work certain groups of muscles are set in action, thereby producing a corresponding excitation in the central nervous system. Muscular fatigue takes place, therefore, partly on the muscular periphery and partly at the brain center, and the more demand is made on the brain center, the greater the final fatigue. Purely mental work creates a demand on the large brain, which means a gradual exhaustion of the gray matter and a certain demand on the nervous ganglia connected therewith. In either case, however, sooner or later exhaustion of the organs brought into action follows.

Moreover, there is a close connection between physical and mental fatigue, and it is a well-known fact that when the body is overtired for any considerable length of time, this also reduces the ability of the brain to do mental work. The reason for this is clear. All work may be physiologically considered as a process of consumption which calls into play not only the organs directly producing the work, but, more or less, all the energy reserves of the body. Hence bodily exhaustion will gradually lead also to mental exhaustion, and an overburdening of one part of the body by products of fatigue will necessarily sooner or later affect the operating ability of all the other parts of the body.

Fatigue is only a moderate degree of the lowering of the producing ability of the body due to exhaustive work. A greater degree thereof is known as exhaustion, and the difference between the two is stated as follows: Fatigue leads to the lowering of the ability to perform work; exhaustion represents a state at which the performance of work becomes entirely impossible. Physiologically, exhaustion represents such an accumulation of the products of fatigue that the body is unable to reconstruct itself for the time being.

A clear difference must be made between fatigue, which is an objective phenomenon, and represents the actual failing in the ability to perform work, and the subjective feeling of fatigue, namely, tiredness. Whereas fatigue is produced by the actual physiological processes of exchange of materials in the body, tiredness may be the result of various conditions and circumstances often lying entirely outside of the effort to produce work. Fatigue is a physiological phenomenon; tiredness, psychological. It may be due to lack of interest in the work performed, outside happenings in the life of the workman, etc.

The degree of tiredness depends mainly on the condition of the workman, and the same amount of effort will produce a greater tiredness in a weak man than in a strong man, in a man poorly nourished than in one well nourished, and in boys and women than in grown-up men.

The paper presents a number of facts in confirmation of the claim often brought out before that there is a distinct connection between fatigue and accidents, although the author makes it clear that he does not consider accidents as being due to fatigue exclusively.

From his data it would appear that in the hours when the fatigue of the workman is still slight there are scarcely any accidents, while in the sections of the working day or week, when the fatigue has grown to an appreciable extent, the number of accidents is more than double the average. Figs. 1 to 3, together with tabular data in the article, would indicate that interruption of the working day by rest periods reduces accidents very materially, and that of all the days of the week, Saturday, the day when fatigue is at its climax, is the worst day from the point of view of accident occurrence. This is particularly apparent in plants which do not employ the Saturday half-holiday.

The following statistics were collected in Lower Frankonia in 1895:

Length of working day, hours	9½	10½	13	over 13
Accidents per 100 workmen	1.1	2.0	13.2	17.0

In printing establishments the accidents for the years 1910 to 1913 were on an average distributed in the following manner, throughout the days of the week:

Sunday	136	Thursday	543
Monday	535	Friday	580
Tuesday	583	Saturday	585
Wednesday	530		

Simple Means of Finding Quantity of Water Required for Concrete or Mortar

By H. G. LLOYD.

From The Surveyor, London, May 7, 1920.

It is a thoroughly well-established fact that every portland cement requires a definite quantity of water in order that it may set perfectly. It is also well known that this quantity of water varies with different portland cements and that, for those manufactured in the United Kingdom, the limits are generally between 18 and 25 per cent by weight of the portland cement. It is further generally acknowledged that the quantity of water which a given cement requires for perfect setting is indicated by the degree of consistency of the cement and water directly they have been mixed together.

The physical tests for judging when the right consistency has been attained are also beyond dispute, so that as far as portland cement is concerned it is quite simple to find out the exact quantity of water which it requires for perfect setting.

Knowing this, as far as neat cement is concerned, the next question is, What is the quantity of water required for portland cement mortar?

If the surfaces of the grains of sands are just damp, then any cement paste which may come in contact with such grains will not lose its water to, or take up water from, the sand, and the object desired will be attained.

The first two steps having been thus indicated—namely, those for portland cement and for portland cement mortar—the third step may be taken dealing with portland cement concrete.

If a mortar of perfect consistency is mixed with a dry large aggregate, the result is that the consistency of the concrete is not the best possible. The dry stones have taken away moisture intended for the mortar, and it is therefore necessary to supply an additional amount of water which will be just sufficient to damp the stones, without supplying an excess, which the stones may not retain.

It is on the assumption that each ingredient in a mortar or concrete should be supplied with requisite amount of water, that the following attempt has been made to determine the quantity of water required by Portland cement mortar or concrete.

It should be borne in mind that the term "consistency" as used in connection with portland cement, mortars, and concrete, does not indicate the quantity of water which is added to the dry materials; it is simply the state of these materials immediately after their admixture with water.

Consistency of Neat Portland Cement.—The consistency of neat portland cement is sometimes described as like "butter" or "putty" or some other plastic material. It is also sometimes referred to as the proper consistency. These descriptions, while giving a general idea of consistency, are not definite enough for the present purpose.

In this case the required consistency is such that the portland cement contains the least quantity of water—no more and no less—in order for it to set completely. For convenience this may be called the "standard" consistency.

The quantity of water which will produce standard consistency varies with different cements. It is usually expressed as a percentage by weight of the portland cement.

The standard consistency may be ascertained experimentally by means of the Boulogne method or the Vicat apparatus.

Consistency of Mortar.—In order to arrive at the percentage by weight of water necessary to be added to the portland cement and sand, it is customary to mix the dry materials and then to add a weight of water known to be less than the requisite amount, and so to continue adding further small quantities until the physical characteristics of the mortar indicate the desired consistency.

This object may be attained by a simpler method, if it is approached in a different manner. This may be best explained by an example. Suppose that a test on a sample of portland cement is to be made in accordance with the British Standard (1915) Portland Cement Specification and that eventually the sample complies with all the requirements. Suppose, also, that it is known that the portland cement requires 22 per cent of water. The mortar briquettes are about to be made in the proportion of three parts by weight of Leighton Buzzard standard sand to one part by weight of portland cement. What quantity of water must be added to the dry materials in order to obtain what may be called the "standard" consistency for this particular cement and sand? If the ingredients are considered separately, it will be seen that, since the quantity of water required by the cement is known, it only remains to find out how much is required by the sand in order that it may have the surface of each grain covered by a thin film of water. In other words, the sand needs damping, so that it may not take the water for this purpose from the portland cement.

The quantity of water required to damp the sand can be ascertained easily in the following manner: Weigh out ½ lb. of dry standard sand; immerse it in clean water in a small bowl; stir it well and allow it to stand. Then pour off the superfluous water and empty the sand onto a clean cloth and wring out the cloth with the sand in it. Screw the cloth up by the four corners and whirl it at arm's length until only ocasional drops are thrown off. Pour the sand onto a sheet of plate glass; then with a small trowel push the sand to one side of the glass. Mop up the water on the glass, push back the sand with the trowel and repeat the process to and fro, mopping the glass each time, while keeping the sand well mixed, until no pools of water remain on the glass and the glass is only just uniformly damp. Weigh out a convenient quantity of the sand, dry it thoroughly and weigh it again; the difference of weight will be that required to damp the known weight of dry sand. The percentage weight can then be calculated. Suppose that it is 4 per cent of the weight of the dry sand. The total weight of water to produce the standard consistency may then be calculated as follows:

1 lb. of Portland cement at 22 per cent = .220 lb. of water.
3 lb. of standard sand at 4 per cent = .120 lb. of water.

4 lb. of dry materials require .... .340 lb. of water.
—i. e., the dry materials require .340/4 of 100 = 8.5 per cent of water to produce a standard consistency.

This may be reduced to a rational formula and thereby the necessity for doing a physical test to obtain the consistency of the cement mortar may be avoided.

Let C = the number of parts by weight of dry Portland cement.
S = the number of parts by weight of dry sand.
c = the percentage of water by weight required by the Portland cement.
s = the percentage of water by weight required by the sand.
w = the percentage of water by weight required by the combined weights of Portland cement and sand.

Then

$$w = \frac{Cc + Ss}{C + S}$$

Consistency of Concrete.—In order to obtain the standard consistency for any proportions of concrete composed of portland cement, sand and coarse material, the same principle may be adopted as in the case of mortar. The quantity of water required to damp the stone may be obtained experimentally in exactly the same way as that described already for sand.

If in addition to the notation in formula (1)

G = the number of parts by weight of gravel or coarse material, and
g = the percentage of water by weight required to damp the gravel.

Then formula (1) for concrete will be

$$w = \frac{Cc + Ss + Gg}{C + S + G}$$

The gravel in this case had been washed and sieved through a ½-in. square aperture mesh and retained on a ¼-in. square aperture mesh sieve. It was then found that this gravel required 1.75 per cent of its own weight of water to damp it. The determination of the quantity of water required to moisten the surfaces of the small stones can be arrived at more rapidly than in the case of sand. In fact, after the gravel has stood in water, then been swung at arm's length in a cloth and tipped on the glass plate, it may not require to be moved about on the plate-glass surface. It is soon apparent if it has been uniformly damped by the amount of moisture left on the glass after the gravel has been moved once. In the case of an impervious material like flint it is clear that only the surfaces are damped. But these surfaces in many rounded impervious pebbles are often irregular, and consequently the wetted surfaces are much greater than might be expected from even a globular pebble. In addition to this relatively large surface which requires moistening there are the cases of materials which absorb water in a greater or lesser degree. Undoubtedly the safest way is to include this absorbed quantity in the total required. If this were not done there would be cases in practice where some of the pebbles would absorb water and thereby take what was required to moisten the surfaces of some of the other pebbles. It is also the case that in certain instances it would be advantageous to the mortar surrounding the pebbles to be in contact with pebbles containing an additional quantity of water, which would tend to keep the mortar damp while it was thoroughly setting, and which at the same time would not affect its consistency.

The Thames sand used in this instance had been washed and passed through a square mesh sieve ¼ in. in the clear and retained on a sieve 1/75 in. aperture. On account of the large proportion of fine sand which this sample contained the determination of the moisture required to damp it took longer than in the case of the hoggin, as the grains tended to bind together.

If a softer consistency than the standard consistency, obtained by the addition of 375 lb. of water to the 5 lb. of materials, is required, this can be obtained by adding an extra percentage to the amount needed for the standard consistency.

If it is desired to obtain the percentage of water by weight to be added to the materials without any intermediate steps, this may be simply expressed by the following formula:

$$y = w + wx/100$$

where w as in (1) = the percentage of water by weight required for standard consistency.

x = the extra percentage, and

y = the percentage of water by weight required for a plus consistency.

If for any reason a drier consistency is required, then a similar deduction from the standard consistency might be named a "minus 10 per cent consistency." The formula would then become

$$y = w - wx/100$$

where x would be the deducted percentage and y the corresponding percentage for a minus consistency

Method of Testing Sand.—An adaptation of the method already described for determining the quantity of water required to damp standard sand in the laboratory may be used for testing the sand delivered to the works. In this case the quantity tested should be greater because the weighing machines used on works are larger.

When determining the water required to moisten the large aggregate on the works a perforated metal box of, say, 1 cu. ft. water content may be used. The weight of this box should be obtained when empty, both dry and when damp, and also when filled with stone. The box filled with stone should be immersed in a small tank, and on withdrawal the water should be assisted to drain off completely by tapping the box, which should then be weighed, then dried and reweighed. A simple calculation can then be made to determine the moisture which the stones require to damp them.

With the information thus obtained the consistency of the mortar or concrete could be agreed upon for various classes of work, and the volume of water for each mixing if by machinery, or each box or banker if by hand, could be decided. On large works the bankers and boxes could be made in sizes to correspond with a convenient number of gallons of water.

A few examples of the plus consistency required for various classes of works are attached:

1. Neat portland cement suitable for pointing brickwork requires a plus 16 per cent consistency.

2. Portland cement mortar made of two parts of Thames sand (as already described) to one part of cement, by volume, suitable for red or gault facing work, if the bricks have been troughed, requires a plus 23 per cent consistency. This is also suitable for all blue bricks, which, of course, do not require wetting. A plus 33 per cent consistency with mortar, made in the same proportions, is suitable for red or gault backing, where the bricks have been troughed or even if they have only been wetted from a hose-pipe. It is suitable for all places where the joints can be rubbed up and for blue brick backing. It may also be used in tunnel work where it is in contact with boards.

3. Concrete 1:2:2 by volume, made of Thames sand (as described) and hoggin passing a ¾-in. square mesh and returned on a ¼-in. square mesh (in the clear), requires a plus 60 per cent consistency. This is suitable for foundations and all positions where a consistency which will enable the concrete to fill cavities and to envelop large stones or projections from heavy castings.

A New Theory on the Method of Constructing the Pyramids

From Indian and Eastern Engineering, Calcutta, India, February, 1920.

The Pyramids of Giza are three in number. Historical research has proved beyond controversy that the first, the Great Pyramid, was constructed about B. C. 3733. All four sides measure in greatest length, at the present day, 775 ft. each, though the original length was at least 20 ft. more. Its height, now 451 ft., was originally about 481 ft. The stone utilized in its construction aggregated about 85,000,000 cu. ft., and, geologically, is of two different kinds, a soft limestone brought from the Mokattam (or Moquatam) Hills, across the river on the other side of the Nile Valley, with a solid outer covering of hard granite brought from quarries in the vicinity of Assouan, about 500 miles up-stream. The limestone blocks weigh from 5 to 7 tons, the granite from 15 to 17 tons. The top is not, as appears in photographs, an absolute apex, but is flattened for a space of about 30 sq. ft. This space was originally smaller, but all investigation goes to prove that there never was a fine point. In view of later remarks, this might be borne in mind. The second Pyramid is smaller. It was built about B. C. 3666 and is in a better state of preservation than the Great Pyramid, inasmuch as a portion (at the top) of the original polished cement-like outer covering still remains. In view of the theory detailed later, this point might also be borne in mind. The third Pyramid was built about B. C. 3633. It is the smallest of the three.

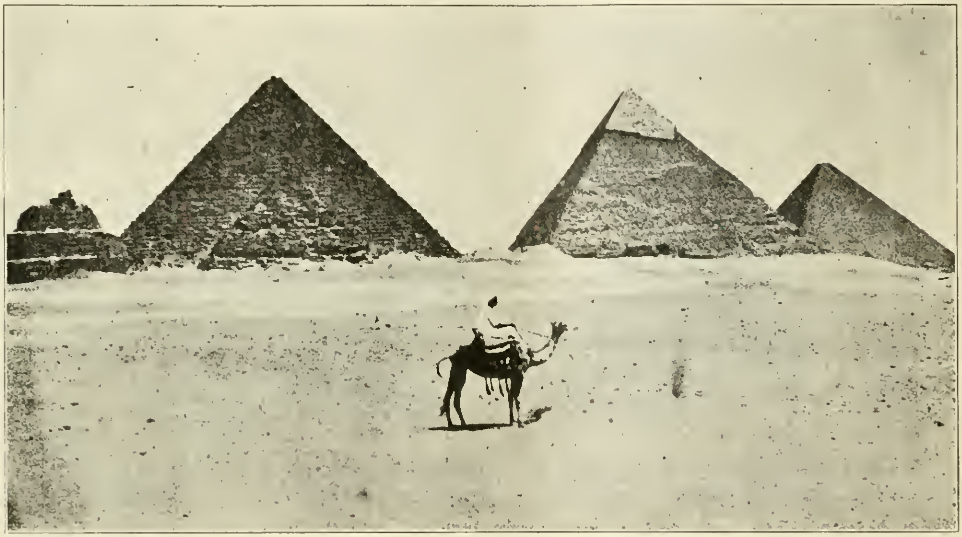
In examining the Pyramids, the problem which has always confronted the engineer has been the method of their construction. It is one of the peculiarities of Egyptian archæology that among the many thousands of specimens of sculpture work on stone, depicting every possible aspect of early Egyptian life and many historical events, which have been excavated, not one has come to light depicting any phase in the construction of the Pyramids—one of the most colossal works ever undertaken by mankind, in that or any subsequent age. There is evidence to prove that the Egyptians of those days had acute intellect and power of geometrical calculation, and also a sound knowledge of dynamics as applied to the construction of buildings. The Pyramids themselves prove this beyond controversy. But no evidence of any kind has been unearthed to show that they had that profound knowledge of mechanics which would enable the construction and operation of cranes sufficiently large and powerful to swing blocks of stone weighing several tons, and place them in position anywhere up to nearly 500 feet in the air. The absence of such proof is only negative of course, but on the other hand, tools of that period brought to light by excavation are of the most primitive kind, and altogether inconsistent with the theory that the people who used them had any knowledge of mechanical appliances. The modern workman does not use flint or roughly hewn copper tools. The high speed tool of tempered steel is contemporary with the power-driven machine. We know that the Egyptians of nearly 4,000 years ago used flint and copper implements, and we know that they would not have done so had their mechanical knowledge progressed sufficiently to enable them to construct and operate power-driven machinery. Again, a people capable of constructing such machinery would also most certainly have had a knowledge of explosives and of applying explosives to the art of warfare. Yet we know that the Egyptians had no such knowledge. The sculpture of the period shows the fighting men of the Pharaohs armed with bows and arrows, or driving in primitive fighting chariots. There is therefore negative evidence to show that no power-driven appliances were utilized in the construction of the Pyramids of Giza, and, also, much evidence that may be called positive, all indicating the same thing.

How, then, were the Pyramids constructed? How were enormous blocks of stone, each weighing many tons, hauled into position up to nearly 500 ft. above ground level? This is the problem which has puzzled engineers. While several theories have been advanced, none has been propounded which has met with anything like general acceptance. The most popular (if it can be so called) is the earth (or rather sand) ramp theory, which propounds that as one row of blocks of stone was laid, from the foundations upwards, an inclined plane of sand was constructed around all four sides, until it was level with the top of the row. Up this inclined plane the blocks of stone for the next row were hauled, and when positioned the sand ramp was lengthened and heightened to the top of them, blocks for another row hauled up, and so on. and so on. In other words, the theory involves a belief that the Egyptians constructed one huge earth mountain to enable them to construct a smaller stone mountain, it being apparent that to get an angle for haulage over soft sand, the approach rise of the ramp would have to commence from nearly a mile away.

To the writer, this idea appears crude in the extreme. Also, it gives very little credit to the master-builders of a very extraordinary age—an age which, so far as it went, showed among the Egyptians the highest civilization then reached in the world or, indeed, reached by any other part of the world for many hundreds of years later. It is not disputed that if the Pyramids of stone could have been raised aloft as they were, a mountain of sand could also have been raised. Millions upon millions of tons of sand could have been thrown up, and probably to a much greater height than that of the highest Pyramid. But the idea is crude, especially as certain evidence exists indicating another, a far simpler and a more ingenious method, which might have been employed to hoist the great blocks of stone into place.

It is known that the Pyramids originally had an outer or surface coating of a highly polished substance, very thick and very hard, like modern cement. This cement covering was, in the case of the Great Pyramid, entirely stripped off in 1357 by the Mohammedan conquerors of Egypt, and embodied in the construction of the Mosque of Sultan Hassan, where it may still be seen. In the case of the second Pyramid, however, that of Chephren, a good portion of the original outer covering still remains at the apex. This can be clearly seen from the photograph reproduced herewith. Now it is generally assumed that the surface coatings under notice were plastered on after the completion of the construction of the Pyramids. The writer believes this idea (other than that a polished coat may have been put on finally) to be erroneous His theory is that the smooth cement covering was put on from the bottom upwards as the work proceeded. That is to say, when the first row of stones above the foundations, i.e., above ground, had been positioned, their outer sides were given the cement plastering. Assuming this to be so, the edifice had a smooth glissade of an ever-rising height as each layer of masonry was added. The object of such a method of construction will at once become apparent if we imagine a roller to have been placed at the angle of the flat top and a number of ropes laid over it down the sides. When the word "ropes" is mentioned, we must calculate upon long lengths, spliced into cables. The fabrication of, say, five such fibrous cables, about ¾ of a mile in length, replaced as worn out, would have been a small undertaking compared with the fabrication of a colossal and totally unnecessary ramp, or huge mountain of sand, the erection and removal of which would have been a titanic operation alone. On one end of those gables would have been hitched a block, already faced and angled, with its smooth side against the cement incline. On the other end, a number of men would have been ranged in lines for hauling.

The number would have been a great one, but history relates that nearly 100,000 men were employed in the construction of the Pyramids. With regard to the hauling of the blocks into position, therefore, the only limits would have been the length of the cable and of the ridge. In such conditions, 10,000 men divided into five rows of 2,000 each, hauling on a 20-ton mass over rollers, against a smooth glissade, would have had an easy job. Once up, the blocks would be hauled to the near side of the haulers, and the process of erection would go on away from them, until the glissade was reached, when the latter would be built up to the new level, and work would begin again positioning another row of blocks.



The Pyramids of Giza (10 Miles West of Cairo). Note the Remains of the Once Smooth Outer Covering at the Top of the Second Structure From the Right.

The theory advanced is supported by several considerations. The modern block and tackle system is unquestionably only an evolution of the very plan of handling heavy weights just described. Both the older and the modern methods required a number of parallel ropes or cables to take off and divide the tension of a very heavy weight, without which division the strain on a single strand would be too much. In each method also, there is the division of the pulling force between several strands. The principles involved are the same, only the modern power or hand-driven block and tackle is more scientific and less cumbersome than the ancient cables working over rollers. But, and here is the point, how much less cumbersome is this method than the idea of mountainous sand ramps, first thrown up and then thrown away?

That the method described was also peculiarly adapted to the science of architecture as then understood in Egypt is demonstrated by a study of the grand chamber in the Great Pyramid. This chamber is a solution to a problem of statics, apparently founded entirely upon the distribution of forces upon parallel lines, and its method of construction is clearly indicative of the extent to which geometry was utilized by the trained Egyptian architect of the olden days. It is worth while describing how his problem was solved. It is apparent that King Cheops desired two rooms; one larger, a kind of ante-chamber, the other smaller, the sepulchere for the sarcophagus. It is with the first we are dealing. To make this chamber rectangular in form would, with 200 ft. of granite overhead, have been to have courted disaster. On the other hand, to have made it pyramidical in its lateral direction would have completely destroyed the imposing effect of the space. The problem was solved by the science of applied statics and geometry, by shelving each layer of stone inwards, to overlap the last along parallel ridges, while a flat roof was preserved by continuing the process until the builder could close it over with single wide slabs of sufficient strength to support the enormous weight above. The angle of incline is along lines parallel with the exterior sides of the Pyramid, to enable the pressure forces exerted to be evenly distributed and to be met, and to counter-balance the tendency to cave in. The effect in torchlight, illuminating the deep and settled gloom of the interior of the Great Pyramid, was the desired appearance of a vast rectangular room, fit antechamber to the tomb of a Pharoah.

The method followed in the construction of this chamber has been detailed at some length, firstly, to illustrate the knowledge of applied statics possessed by ancient Egyptian architects, and, secondly, to show the lines upon which the Egyptian mind apparently tended to work.

It is contended that with all its ignorance of the long subsequent and varied discoveries (?) of Archimedes and Pythagoras, and of our modern use of power-driven metal cables working over blocks and pullies, the same powers of intellectual and geometrical calculation as are evidenced in the grand chamber of the Great Pyramid were brought to bear upon the dynamical problem of constructing the whole edifice. If we allow this, we admit not the possibility, but the strong probability that the Pyramids of Giza were constructed by some very much more ingenious method (the most likely being that described) than the clumsy one, involving waste of time and energy, of rolling stones up a manufactured mountain to get them to the top of another mountain.

First National Convention of British Architects' and Surveyors' Assistants' Union

From The Surveyor, London, June 4, 1920.

The first national convention of the Architects' and Surveyors' Assistants' Professional Union was held at Sheffield, at Whitsuntide, there being present delegates from London, Southampton, Exeter, Birmingham, Cardiff, Liverpool, Manchester, Sheffield, Leeds, Newcastle, Edinburgh, Glasgow and Ayr.

Reports by the secretary and treasurer were received and approved, both pointing out that the growth of the work of the union would necessitate immediately the taking of its own offices, the employment of permanent assistance and an increase of the present low subscription. .

The matter submitted to the Assistant's Welfare Committee was reviewed at length and heartily endorsed. With regard to professional education it was unanimously agreed that this must be wholly in the control of the profession and the building industry, and that the present system of articles and apprenticeship must go in toto. The proposals as to minimum wages were approved, and generally felt to be fair and not excessive. Other matters decided were the imposition of an entrance fee at an early date at the discretion of the executive; an increase in the subscription subject to a ballot of the members; registration under the Trades Union Acts in order to give the union legal status; the setting up of a divisional council for Scotland to deal with conditions of employment and to set up an employment bureau. The proposals of the Ministry of Health with regard to "luxury" building were emphatically condemned, and the action of the executive in the matter endorsed. The practice of local authorities employing non-professional men to do professional work was very severely condemned, as also the very general practice of designating qualified architects and surveyors as assistants or draftsmen instead of as assistant architects or assistant surveyors. The executive were instructed to watch the interests of non-practicing members of the profession under any scheme of registration. It was also an instruction to the central executive to prepare a scheme by which the special interests of the members, whether employed in private, government, municipal or industrial offices, might best be served.

Marine Boring Animals and Submerged Structures

From Water and Water Engineering, London, May 20, 1920.

The Natural History Department of the British Museum has recently issued another pamphlet in its Economic Series. The present contribution to this series is the work of Dr. Calman, and treats of marine boring animals, a subject which is of particular interest to those responsible for the construction and upkeep of harbor works, and other marine structures.

The habit acquired by various classes of marine animals of boring into wood or rocks has been prompted by the instinct of concealment which many inhabitants of the sea have inherited as a protection against their enemies. In the majority of cases recourse is had to burrowing into the soft sea bed. The more elaborate process of excavating shelters in hard material necessitates the possession of a suitable mechanism for the purpose, the nature of which is not yet, in all cases, completely known. Dr. Calman recalls the fact that the shipworm has been known since the earliest days of ocean navigation. Its ravages were recognized in the triremes of Athens, and its activities have baffled marine engineers of all ages. Even the casing of sumarine cables has been attacked; and the fact that the Institution of Civil Engineers is on the point of presenting a practical report upon the subject is sufficient indication of the importance which engineers attach to this particular evil.

How the Teredo Excavates Its Burrow.—Certain marine crustacea, as well as some mollusca, are mainly responsible for these depredations. The shipworm, belonging to the Teredinidae, does not confine its attack to wooden vessels, but has been a source of trouble to timber work, as for example, in the dykes of Holland. Much attention has been given to the natural history of this order, of which more than thirty species have been described, among which the species Teredo navalis is the most commonly known. Dr. Calman provides a detailed description of this mollusc, which belongs to the family of the Lamellibranchs. In what manner the Teredo excavates its burrow has been much discussed, but naturalists are now generally agreed that the shell of the animal is the boring organ, the rasping sound of which can often be heard when the ear is applied to timber infested with this organism.

It is a remarkable fact that, however closely packed they may be, the burrows excavated by Teredo never run into one another, but are always separated by a wall of timber. Each burrow usually starts at right angles with the grain of the wood for a short distance, and then turns along the grain, usually in an upward direction in the case of vertical piles. Woody matter is found in the food-canal of the animals inhabiting the burrows; but it is not, on this account, proved that they feed on the wood rather than on the plankton of the sea-water during the process of boring. In any case, they must be dependent upon the plankton in the later stages of their existence, because the burrow is ultimately lined by shelly matter, which has the effect of shutting off the animal entirely from the wood.

The infection of timber previously untouched is due to the fact that the larvæ are free swimming organisms, developed from eggs discharged from adult animals. When the young Teredo finds a place suitable for boring, it attches itself by means of a sticky thread, called the "byssus," and starts immediately to scrape away the fibres of the wood by means of the edges of its cockle-shaped valves. In this way it soon envelops itself in a mass of woody particles and is lost to sight, being at this stage less than 1/100 in. in size. The first formed hole is, therefore, little more than a pin-hole, and the entrance to the burrow remains of this size even after the animal is full grown within the wood. Thus, the timber may appear outwardly sound, even when the interior is riddled with burrows. Measurements made at Plymouth showed that burrows 11 in. in length can be excavated in 31 weeks, and the full-grown animal may be from 12 to 16 inches in length in a burrow about ⅕ in. in diameter. In Australia a species allied to Teredo navalis has been recorded as having a length of 5 ft. 10 in., in a burrow between ¾ in. and 1 in. in diameter. The attacks of Teredo are not confined to wholly submerged timber, but may reach to half-tide level. In depth the range is not precisely known, but telegraph cables are said to have been attacked by Xylophora, an allied genus, at a depth of 1,500 fathoms.

Observation has established the fact that attacks are less likely in contaminated water, such as sewage or factory waste outfalls. Brackish water, also, is inimical to Teredo navalis, and in the Zuyder Zee the worst outbreaks have been associated with a high salinity of the coastal water, due to deficient rainfall. Similar epidemics of Teredo attacks have been associated on the Pacific Coast of America with a reduced flow of the rivers. But, on the other hand, certain tropical species are said to be indifferent to the salinity of the water. The vitality of Teredo navalis seems to be high, since living forms have been found in wood which has been removed from the water for a fortnight.

Other Forms of Marine Wood Borers.—In addition to the Teredo family, certain species of Pholas are wood-borers, although the majority of this family attack stone in preference. Of the wood-boring Phaladidæ the best known in British waters is Xylophaga, which is said to have done serious damage to the dock gates at Ardrossan, on the Firth of Clyde. Faults in submarine cables, also, due to the destruction of the insulation, are sometimes caused by this species.

Of a totally different class is another marine wood-borer called the Gribble, a small crustacean of the same order as the common wood-louse. This animal was found by Robert Stephenson to be a destructive agent of the timber used in the erection of the Bell Rock lighthouse in 1814. The gribble or Limnoria lignorum is, in fact, very like a miniature wood-louse, about ⅛ in. in length. It makes burrows about 1/20 in. wide, extending obliquely into the wood for 1½ in. to 2 in., and rapidly reduces the outside of the timber to a spongy mass about ½ in. thick. The removal of this layer by the waves exposes another layer to attack, until the timber is completely destroyed. Its favorite habitat is a zone between low-water and half-tide. It has also been found attacking submarine cables in the Mediterranean at a depth of 290 fathoms. The gribble has a wide distribution on temperate and sub-tropical coast-lines, and is apparently indifferent to the degree of salinity of the water, so long as this exceeds 2 per cent. It is not infrequently associated with Chelura terebrans, another wood-boring crustacean of equally destructive tendency.

In warmer seas another crustacean, Sphaeroma terebrans, has been found attacking wooden piles in Florida and elsewhere, even in localities where the water is practically fresh. It is a remarkable fact that both the wood-boring mollusca and the crustacea appear to be indifferent to the nature of the wood, the harder varieties, such as oak and teak, being attacked as readily as the softer coniferous woods. Woods like eucalyptus, containing a essential oil, or greenheart, containing alkaloids, offer a temporary resistance, but even these are ultimately destroyed. The best protective measures include surface application of pitch, tar or paint, and charring has also been recently recommended. Metal sheathing and cases of concrete or cement have also been used for piles, and in pier and harbor works the process known as "scupper-nailing" has been found to be a protection. Creosoting, also, is beneficial in the case of soft woods, if care is taken to secure a heavy impregnation.

Stone-Boring Crustaceans.—Coming next to stone-boring animals, these are more numerous than the wood-borers, but their destructive effects are more noticeable in promoting the disintegration of rocks than of engineering structures. Pholas dactylus, or the piddock, is the best known, but its action is confined to the softer rocks, such as limestone and the less indurated sandstones. Boring is effected by the rasping action of the shell, as in the case of Teredo. But another mollusc, the Mediterranean date-shell, Lithodomus lithophaga, which attacks calcareous rocks only, possesses an acid-secreting gland, and excavates its burrows by purely chemical means. In the case of Saxicava rugosa, a rock-boring mollusc common to the British coast, the boring mechanism is not so clearly evident. Its attacks are most frequently seen in limestone rocks, but it is said to have been found attacking soft sandstone, in which case the secretion of acid cannot have afforded any assistance, neither has any special acid-secreting gland been found in this species. Among other rock-boring animals, Dr. Calman mentions the crustacean Sphaeroma quoyana, reported from Australia and New Zealand; the "worm" Polydora, which attacks limestone rocks on the British coasts, and the sponge, Cliona celata, which is believed to act upon limestone rocks by some solvent process.

Of the damage which these stone-boring animals do to engineering structures, the most notable instance is that of the Plymouth breakwater; but upon the degree of damage done by this agency there is some difference of opinion. Dr. Calman quotes a report upon this subject by Dr. E. J. Allen, which runs as follows: "In a stone which has been injured through this cause, the outer surface, to a depth of about a quarter of an inch, is converted into a honey-combed friable mass through the ravages of the boring sponge Cliona celata, while at frequent intervals larger holes, each of which may have a diameter of a quarter of an inch, and may pierce the stone to a depth of 1 in., are formed by the boring mollusc Saxicava rugosa. To these two animals most of the damage is due," but other holes have been bored by various species. Dr. Calman reproduces an illustration of a section of limestone from Plymouth breakwater which clearly shows the nature of the damage caused by this means.

Attention is also directed to the well-known case of the harbor works at Wairoa, Hawke's Bay, New Zealand, made of a kind of claystone, known as "papa rock," which has been rendered so porous by the attack of Isopods that the wall in places has disappeared, and blocks of concrete laid upon the same kind of rock have sunk several feet owing to the destruction of the foundation.

Dr. Calman raises the question whether concrete itself is liable to similar attacks, as has sometimes been stated, but he has no evidence bearing upon the point. Clearly, however, the selection of material for submarine construction should be made in the light of existing knowledge as to the dangers arising from this cause.

Waterworks for a Tropical Town

From Concrete and Constructional Engineering, London, May, 1920.

Adequate and reliable water supply for the towns has long been recognized as an especially important factor in conserving the health of the people in tropical and sub-tropical regions. Through the provision of such, and through improvements in drainage and other sanitary measures, the British authorities have made of the Gold Coast Colony, on the Gulf of Guinea, a region habitable for Europeans for the greater portion of the time.

One of the important works carried out in this process of making the Gold Coast a fit place to live in, was the provision of a water supply for the town of Seccondee, next in importance to Accra, the capital. There is in this work much that may be of assistance to those who have to deal with situations involving unusual difficulties of purification.

Preliminary Investigations.—The pioneer work of collecting data upon which water supply projects could be based was done some 15 years ago by British engineers. It was found on a careful examination of rainfalls and the gaugings of streams, that, in years of low rainfall (such, however, as would be called a large rainfall for the east coast of England), the run off was so small that a catchment area which in England would afford a large supply with ordinary storage might fail altogether in the Gold Coast, even though storage to meet the demands of several years were provided. It was, therefore, necessary, in order to obtain even so small a quantity of water—about 500,000 gal. per day—as would satisfy each of the towns of Accra and Seccondee, to utilize streams which, though in occasional years altogether empty in the dry season, assumed the character of considerable rivers in the wet season. Such a stream was found in the River Densu for the supply to the town of Accra, and the works were finished in 1914-15.

For the town of Seccondee, the Anankwan River was selected, a reservoir being formed in the river bed near the village of Inchaban, at a distance of about 3½ miles, in a straight line from Seccondee. The needs of the town were considered up to the year 1924, when it was estimated that the quantity of water required would be 658,500 imp. gal. per day, and the works were designed in the first place to afford a supply of 500,000 gal. per day. From the available data, the estimated average rainfall worked out at about 43 in. per annum, and the available supply from the river was calculated to be 1,040,000 gal. per day, so that the required supply was only 66 per cent of that available. The water is of low mineral content, but is highly charged with organic matter, chiefly of vegetable origin. It was, therefore, necessary that it should be filtered before being used.

The works consist of a concrete dam with outlet works and sluices for passing floods, filters, clear water tank, pumping station, service reservoir and the necessary mains and contingent works. The site of the reservoir is almost at the sea coast. Unfortunately there was no suitable site farther upstream, consequently the reservoir had to be made at this low elevation, and pumping machinery introduced to lift the water to a service reservoir high enough to supply the town.

The Dam.—The dam is 360 ft. long, with a maximum height above the original surface of the rock in the river bed of about 40 ft., and two large sluices are provided in the center for passing flood water. Flood water can also be passed over the top of the dam, but the intention is to use the sluices as much as possible, so that the less pure water which settles to the bottom may be scoured out from time to time. The structure is faced with concrete blocks in courses 2 ft. deep, the upstram blocks being smooth-faced and the downstream blocks rock-faced. The main body of the dam between the blockwork is of 1:6 mass concrete containing displacers, which were specified not to exceed 1,700 lb. in weight. As a matter of fact, however, owing to the nature of the schistose rock forming the foundation of the dam from which the stone for the dam was taken, it was not possible to get displacers of material size. The blocks have a face 3 in. thick of 1:3 concrete, the remainder of the block being 1:5 concrete. The concrete work round the sluices is 1:6 faced with 1:3 fine concrete. The cement and aggregates were so proportioned that the 1:3, 1:5, etc., concretes practically mean that in the finished work the bulk of the cement is a third, a fifth, etc., of the whole volume.

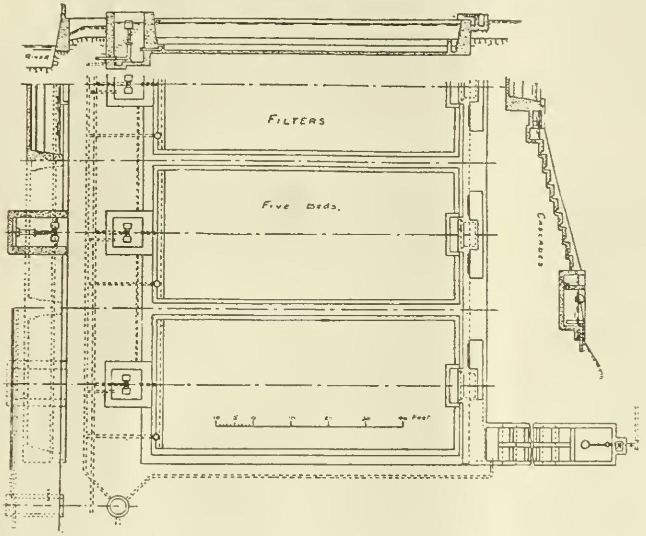


Fig. 1—Filters for Water Supply of Seccondee.

The sluices are on the Stoney principle, each having an opening 26 ft. deep by 18 ft. wide; they are built up of wrought steel plates and sections with the necessary roller paths and rollers; an adjustable bar is provided along the top so as to close down on the lintel and make a practically watertight joint; adjustable bars are also fitted to the sides of the sluice so as to reduce the leakage. The sluices are designed to withstand a head of 45 ft. above sill level, and each sluice is counterbalanced and provided with lifting gear so proportioned that two men can raise the sluice with the full head against it.

The concrete blocks were made in molds on the works, and while the blocks were being cast the molds were placed on a shaking machine, so that they were kept in a constant state of agitation during the process of casting the concrete, thus insuring a dense and watertight mass. Recesses were formed in all vertical joint faces of the blocks, these recesses being filled with cement grout after the blocks had been set in the dam, thus dowelling all the blocks together. The blocks were left in the molds for seven days after casting, and were then taken out and set in the air for a further minimum of 28 days before being used in the work; 1:3 portland cement mortar was used for setting the blocks in the dam.

It was specified that the blockwork should be kept a course in advance of the mass concrete so as to serve as forms and render the use of timber forms unnecessary in the construction of the dam. The mass concrete was to be worked well up against the back of the blockwork to ensure thorough bonding. In actual construction, however, this method was not adhered to, a novel one, consisting in building a series of longitudinal walls, being adopted upon the advice and responsibility of the engineers in the colony who were in charge of the work.

Access is given to the sluices by means of a roadway carried on eight arches supported on concrete piers built up from the top of the dam from the north end. The faces of the sluice piers and of the parapets of the roadway were brushed in panels, leaving the aggregate in relief, to improve the appearance of the work.

The ends of the dam are recessed to form keys for puddle walls, which are carried upstream for a considerable distance parallel to the water edge of the reservoir in order to prevent leakage, as the rock does not rise to the full height of the water in the reservoir, and it was found that the ground above the rock was not sufficiently impervious. It was thought possible that a puddle wall would have to be carried round the whole periphery of the reservoir, but a comparatively short length at each end has proved to be sufficient.

Outlet Works.—The outlet works are situated at the north end of the dam, which is made 14 ft. thicker at this point, and a well 10 by 8 ft., and a screen chamber 12 by 3. ft., are formed in this thickened portion. The banks of the reservoir are cut away to allow easy access of the water, and the slopes so formed are covered with grouted pitching. The water passes from the reservoir through the screens which are of two kinds, the outer being of iron bars spaced to give 1 in. clear between them, and the inner ones of copper wire gauze having 400 metshes to the inner ones of copper wire gauze having 400 meshes to the well is by four 12-in. bell-mouthed pipes each leading through two sluice valves, in series, to a 15-in. upstand pipe. These 12-in. pipes are at different levels to admit of the water always being drawn off near the surface. The supply pipe is taken through the dam from the lower end of the upstand and is 15 in. diameter through the dam, below which it is reduced to 12 in. diameter.

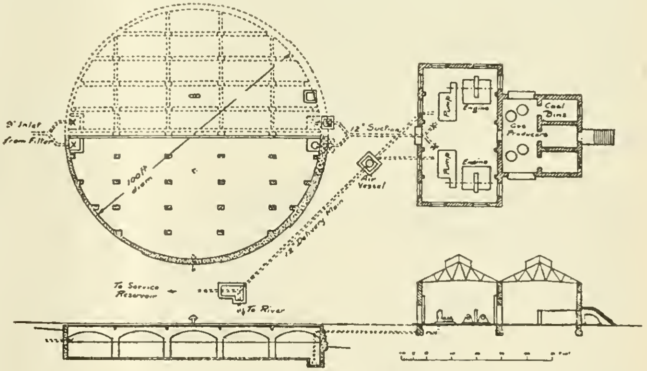


Fig. 2—Clear Water Tank and Engine House.

In order to facilitate construction, a timber gantry 30 ft. wide was built on the downstream side of the dam, the rail level on the gantry being 15 ft. below the crest level of the dam. On the side of the gantry near the dam a 7-ft. crane road was placed and on the farther side two lines of rails of 2-ft. gage, one for conveying the concrete from the mixer and the other for returning the empty trucks.

Concrete Cistern and Aerator Cascades.—The raw water from the reservoir passes through the draw-off main to a concrete cistern 10 by 9 by 6 ft., the flow into which is regulated by means of a ball valve fitted on the end of the pipe and capable of passing 750,000 gal. in 24 hours when fully open. There are two 6-in. outlets from this cistern, feeding a double row of cascades, 10 in number, introduced for the purpose of aerating the water, which are used to regulate the flow to the filters in accordance with the varying seasonable demands. A 6-in. overflow pipe is provided in the lowest basin of the cascades and is fitted with a valve, this pipe being used for washing out when required. From this basin the water passes along a channel running across the top of all the filters and supplying them through feeding chambers in the form of cascades.

The Filters.—There are five filters each 80 by 35 ft. by 8 ft. 6 in. deep (see Fig. 1), which for the greater part of their area are founded direct on rock, but, where the rock falls away, concrete walls are built up from the rock and the spaces between them filled with rubble stone to form the foundation. These supporting walls are 1:7.4 concrete, while the main body of the filters is of 1:6 concrete. The internal surfaces of the filters and filtered water wells are rendered with 1:2 cement mortar.

The filtering material is supported on two layers of concrete bars 3 ft. by 4½ in. by 3 in. The bars in the lower of the two layers are laid on the flat, in rows 4½ in. apart. The bars in the upper layer are laid at right angles to those below, but closer together, only a small open joint being left, by which the filtered water drains to the ducts in the lower layer and is led to the outlet wells. In order to keep the bars in place notches are made in the under side of the upper ones into which the lower bars fit. The filtering material consists of 6 in. thickness of broken stone ⅞ in. to 1¼ in., laid on the concrete bars, then 6 in. of stone ⅜-in. to ¾-in., then 2 ft. of sand in two 1-ft. layers of different grades. There is a discharge well 8 ft. square at the bottom end of each filter, the water entering through a 6-in. inlet valve. Each of these wells also contains a Glenfield-Jones regulating valve to ensure uniform delivery within the limits of head allowed in the filter. These valves discharge the water through 6-in. pipes into a 9-in. filtered watermain leading to the clear water tank.

The filters are roofed with reinforced concrete 4 in. thick, carried on reinforced concrete beams 6 in. wide and projecting 8 in. below the underside of the roof slab, and spaced at 8-ft. centers, the ends of these being supported by beams 12 in. wide and 1 ft. 8 in. deep below underside of roof. These are, in turn, carried on concrete arched walls situated between the filters and by concrete columns 1 ft. 6 in. by 1 ft. situated on the center lines of the filters. The reinforcement consists of four 1-in. square indented bars in the main beams, three ⅝-in. round bars in the cross beams and No. 8 expanded metal in the roof slab. Each filter is provided with five pairs of doors. The filters being situated on the river bank are protected on three sides by a training wall of 1:6 concrete founded on the rock.

Treatment for Bacteria and Algal Growth.—The water of these tropical countries is organically highly impure, chiefly through decaying vegetable matter. The problem of filtration was, therefore, a difficult one. At the Accra works it was hoped that by the adoption of multiple filtration a pure filtrate would be obtained without the use of chemicals. While the system succeeded in materially reducing the impurities, it did not afford a water of the standard desired. It was at one time intended to add the iron process, but there were objections to it. Ultimately, on the advice of Sir Alexander Houston, it was decided to adopt the excess lime process, the character of the water being suitable. It was stated by Sir Alexander Houston that the lime would destroy practically all bacteria, and also algal growths which were very troublesome in the reservoirs. It has been reported from the Colony that the process has met with complete success, and it has been adopted also at Seccondee. The water is, of course, filtered through the sand filters after treatment with the lime.

Clear Water Tank.—The clear water tank (Fig. 3), to receive the water from the filters, is circular in form, 10 ft. internal diameter and 11 ft. 6 in. deep, of 1:6 concrete, and is excavated partly in rock and partly in earth; where in rock the walls are 1 ft. 6 in. thick, and where in earth they are 3 ft. thick at the bottom and stepped up to 1 ft. 6 in. at the top. It is covered with a concrete roof 6 in. thick, reinforced with No. 10 expanded metal and supported by concrete arches at 10 ft. centers carried on concrete piers 2 ft. 6 in. by 1 ft. 6 in. A center wall 6 ft. high is provided so that half the reservoir can be laid off for cleaning when required; the inside of the tank is rendered with 1 part of cement to 2 of fine sand. The whole tank is below the ground and is covered with soil 12 in. thick. The 9-in. pipe from the filters divides into two pipes just outside the tank so that either half can be filled while the other half is being cleaned; each branch is fitted with a 9-in. sluice valve. Two ventilators and a 9-in. bell mounted overflow leading to the river are provided. The water is withdrawn from the tank by two 12-in. suction pipes which join just outside the tank and which lead to the pump house, which is close to the tank.

Engine House and Pumping Equipment.—The engine and pump house is 54 ft. long by 30 ft. wide. internally, and is constructed of concrete blocks 16-in. thick made in a Winget block-making machine; the roof is supported by steel trusses. At the back of the engine house is a gas producer house 30 by 30 ft.

The pumping machinery was supplied by Messrs. Tangye, Ltd., and consists of two sets of horizontal treble ram pumps, with rams 13-in. diameter by 15-in. stroke, running at 33½ r.p.m. and drives through gearing by two sets of horizontal suction gas engines of 108 maximum b.h.p. running at 200 r.p.m., these being supplied from two suction gas producers. The pumps draw water from the clear water tank, the level in which varies from 10 ft. to 20 ft. O. D.. and deliver it into a standpipe at the service reservoir about 1 mile from Seccondee, the overflow of which is 225 ft. O. D.

The delivery main from the pumps is of 12-in. spigot and socket cast iron pipe and conveys the water to the service reservoir; the main is bifurcated just before entering the service reservoir, the branches delivering one on each side of the reservoir division wall, and each being provided with a sluice valve. Just before the bifurcation a standpipe 30 ft. high, above the center of the pipe, is fixed, so as to enable a higher head to be put on the main for the supply of villages along the route; it also serves the purpose of a safety device in case the valves on both branches should have been left closed. The pipes were all tested to a head of 600 ft.

Service Reservoir.—The service reservoir is circular in form, partly excavated and partly built above ground. It is 175 ft. internal diameter and 12 ft. deep from floor to underside of roof, the maximum depth of water to overflow level being 11 ft. It has a center wall 7 ft. 6 in. high above the floor to enable half the reservoir to be emptied for cleaning. The floor is 12 in. thick and the walls 2½ ft. at the bottom, stepped off to 1 ft. 6 in. at the top, all of 1:6 concrete. The roof is 6 in. thick of concrete reinforced with No. 10 expanded metal and is carried on concrete piers and arches, the arches being 20 ft. span and 10 ft. apart. The roof is covered with soil 12 in. thick sloped off at 3 to 1 all round to meet the original ground. The water leaves the service reservoir by two 12-in. pipes, one from either side of the division wall. These join at about 30 ft. from the reservoir, and about 22 ft. beyond this junction a Venturi meter is fixed for the purpose of recording the delivery to the town. The Venturi meter is situated in a house made of concrete Winget blocks. The 12-in. main is continued to a point in the town where it divides into the general distribution system. Two 9-in. Deacon meters are fitted on the distribution system for detecting waste

The completion of the works was much delayed owing to the war, and the cost, consequently, considerably increased.

In order to facilitate the construction a branch railway, about 3½ miles in length and of the same gage as the main line, was built to the site of the dam. It cost $84,000.

The water is introduced to the bungalows of Europeans, and the natives are supplied by street fountains placed at frequent intervals.

The work was carried out in accordance with the plans of Hunter, Duff & Middletown, consulting engineers.

The Art of Systematic Inquiry

By DR. H. E. ARMSTRONG.

From Engineering, London, May 28, 1920.

In what does the Art of Inquiry consist? We must suppose that, like other arts, it has been evolved. It has been systematized only for a century or so, but its origin must go back to very early times, when intelligence was beginning to dawn upon mankind, for without inquiry progress is impossible.

Little if anything has been done to develop and extend the art of inquiry; the teaching of the Church and of the schools for the most part has been frankly dogmatic, the pursuit of truth being evaded, not encouraged. The task before us is to overcome this lack of outlook.

Science—"Organized Commonsense."—The method of science is in no way peculiar—it is the judicial method, the method of the logician applied to practice, the method of the detective; Huxley called it organized commonsense. The shilling-shocker detective story is universally popular—because it deals with human doings. But who wishes to read a detective story dealing with the discovery of the nature of the crime committed, let us say, when iron rusts? Yet it may well be regarded as a murder of the cruelest kind, as the valuable strong metal is changed into a worthless powder. This is one reason why science makes so little headway; another is that it is necessary to know a great deal, if effective use is to be made of science the problems being rarely simple. But the principles of scientific method are of universal application and within the range of ordinary intelligence; it is these we need to bring home to the general public. Facts, more facts, all the facts in the world, if not what we ask for, is all we receive from the schools. The curse of books is too much upon us. The way knowledge is won, still less the way knowledge is to be used, is not taught. The teacher parrot is easily found; the teacher who will refrain from teaching, who will force his pupils to learn and develop them as observant, thoughtful, reasoning beings is almost unknown. No training being given in the art of inquiry, teachers cannot be expected to be inquirers or to lead others to inquire.

We shall only succeed in developing the intellectual faculties when we seek to develop them on the lines on which handicrafts are developed—through practice and not through prating. However many new buildings we may put up, we shall make no progress, unless we improve our methods of teaching and make them practical.

Huxley long ago summarized the position in saying that, "The great aim of life is not knowledge but action." The knowledge gained in the schools should be of such kind, the training given so imparted, that both subserve the purposes of action, bearing in mind that, as Thring, a prince among teachers, insisted, "the whole human being is the teacher's care"—that we have to educate for the home as well as for wage earning.

How the Art of Inquiry May Be Taught.—Practice is always better than precept. In showing how beginners may be taught method, there must be some definite object in view, some definite problem to be solved, such as the examination of limestone, one of the commonest and most useful earthy materials. How would a detective proceed in such a case? He would endeavor to ascertain the facts of the case and pick up some clue which can be followed. Limestone is clearly the stone which contains or gives lime. Lime is made in lime kilns by burning limestone, either by putting alternating layers of limestone and coal in the kiln, or by passing the flames and heat from a neighboring fire up through the kiln filled with pieces of the stone. The heat seems to enter the stone, but it seems strange that it should be expelled by wetting; for usually when substances are burned and reduced to ashes all life seems to go out of them. The lime burner can give many items of information, but none which seems to afford any very definite clue which can be followed, unless, indeed, he happens to say that the quantity of limestone put into the kiln is a good deal more than that taken out as lime. Dry chalk is weighed out in a suitable vessel (such as a porcelain crucible) and heated in a muffle furnace, then cooled and weighed again. The heating, cooling and weighing are repeated until no further change takes place. The loss is over 100 per cent, and repetition of the experiment would show that the same loss is always sustained, whatever heat may be applied, for the same kind of limestone. If students are being instructed, they should write out beforehand the reasons for making the experiment, and also record all they observed during the experiment. The results obtained also afford an opportunity of driving home certain lessons on the interpretation of numerical values, which have a bearing on ordinary business practice. From the actual results an average value is obtained. Usually about half the results of different experiments differ from the mean or average on one side and half on the other side. Further experiments would show that other materials, whether Bath or Portland stone or carboniferous limestone, would not differ materially from chalk. Only lias limestone is found to give a considerably smaller and very variable percentage of lime; but this variety is obviously "dirty" in appearance.

Thus the conclusion is established that the formation of lime depends on the expulsion of something from the limestone.

The stalactites and stalagmites are also found to give lime when burned, and lose nearly 44 per cent—rather more than ordinary limestones lose. Calc spar or calcite—crystalline material filling up cracks in limestone rocks—also gives lime when burned, losing about 44 per cent of its weight. It is difficult to resist the conclusion that this is the pure material of limestone.

It may next be asked how is limestone formed? Chalk when seen under the microscope is seen to be full of shell remains; shell remains are recognizable in most limestones, usually sea shells, but sometimes the limestone is largely composed of fresh water shells. Some limestones are full of coral remains, and coral is formed in the sea. Clearly limestone has been laid down under water, and it would seem that shells must be made of limestone. It is found by experiment that very good lime is obtained by burning almost any kind of shell, whether sea shells, fresh water shells, land shells, or egg shells, and the percentage of lime obtained is nearly as much as from limestones. The Challenger people dredged from the floor of the Atlantic, at depths of 2,000 ft. or more, an ooze very like chalk in appearance, and the minute shell remains in it were the shells of organisms living at the surface.

The lime obtained from limestones, if carefully weighed before and after slacking, is found to weigh more, about in the proportion of four to three, and nothing is lost on heating to a temperature at which water is easily driven off, but only at a considerably higher temperature. If this higher heating be continued, the lime again becomes "quick" and has the same weight as before.

In preparing mortar, the lime and sand are mixed with water, and some action takes place between the two solids. As regards possible action of water, it is easily found by shaking sand or lime with water, filtering off, and evaporating some of the clear liquid, that little if any sand is dissolved, but the lime water leaves a substantial residue. The solution has a sweet taste, and lime water is commonly given to babies. On shaking some finely-powdered limestone with water, filtering and evaporating the clear liquid, very little solid matter remains, limestone thus being far less soluble than slaked lime.

Discoveries have often been made incidentally by following up some chance observation. The X-rays and radium were chance discoveries, and so was the discovery of argon in air.

In making lime water, it is difficult to prepare a clear solution, for the clear liquid soon becomes covered with a skin when exposed, and in time quite a crust is formed on the liquid. Black, 150 years ago, concluded that the deposit was due to the lime attracting something, which he called fixed air, from the atmosphere. Black knew that calcareous earths, in their native state, effervesced violently when mixed with acids, while quicklime dissolved quietly, from which he concluded that limestone contained a large quantity of "fixed air" which it gave up when sufficiently heated. The modern student, having found that limestones effervesced with acids and, according to their purity, lost up to 44 per cent in weight, would both measure and weigh the gas given off, and would subject the precipitate from lime water to similar treatment. He would have to think out ways of making the experiments.

The close correspondence thus established between the loss in weight when limestone is burned and the weight of the gas given off when it is dissolved in acid, taken in conjunction with the behavior of lime water on exposure to air, and the similarity of the precipitate to limestone both on ignition and when dissolved in acid leaves little doubt that the conclusions already arrived at that limestone consists of lime in association with the gas called fixed air by Black.

Curiously enough, Black never carried his experiments so far as to establish the correctness of his conclusion by associating the gas given off on dissolving one portion of limestone in acid with lime formed by burning another portion and so reproducing the material of which limestones are mainly and calcite entirely composed. The modern student detective would necessarily seek to obtain this evidence. He would simply bring the gas in contact with lime water, and finding a precipitate produced, he would prepare enough to determine its precise nature when heated and when dissolved in acid, and thus establish its identity with Black's fixed air.

But instead of passing the gas directly into lime water, having heard that ordinary so-called soda water is made by passing similar gas into water he might for convenience add soda water to lime water. Finding a precipitate was produced, he might go on adding the soda water, hoping to produce more. Then would come the chance discovery that the precipitate is dissolved by excess of the solution. This important result affords a clue to the deposition from hard waters, and to the production of caves in the limestone.

The foregoing demonstrates the way in which the art of inquiry may be taught, how question after question may be asked, and the answers obtained by direct experiment. Such training develops habits of thought and the habit of looking into things, and the tendency is thus acquired to ask for definite evidence in proof of statements made.

Land Drainage in England from the Engineering Point of View

By C. H. J. CLAYTON.

From Water and Water Engineering, London, March 20, 1920.

Water which falls from the clouds upon a catchment area has three immediate and two ultimate means of dispersal. The immediate means are: (1) Infiltration or soakage into the soil; (2) evaporation from the surface into the air; and (3) run-off from the surface into the sea. The ultimate means are evaporation and run-off only, because the reservoir capacity of the soil is limited by physical circumstances which manifest themselves in the form of land springs so soon as the underground reservoirs are full to overflowing.

The possible conditions are so variable that, while no general rule can be laid down, it is permissible to assume that in average areas in England the discharge to sea is from 50 per cent to 60 per cent of the total rainfall. As the general average rainfall is about 32 in. per annum, and as each inch represents an approximate weight of 100 tons or an approximate volume of 3,600 cu. ft. per acre, the water falling upon an acre is 3,200 tons or 115,200 cubic feet, of which, roughly, 1,800 tons or 64,000 cu. ft. runs off by rills, brooks, streams and rivers, and ultimately finds its way back into the ocean from which it was originally evaporated.

Capacity of Main Drainage Channels.—In considering the capacity of drainage channels, it is necessary to take into account the occurrence of wide divergencies from the average. Between 1835 and 1843, for example, the mean rainfall for the months June to November inclusive was 61 per cent of the total, while it is notorious that many of the most destructive floods have occurred during the months of July and August. One of the most serious floods of recent years was that of Aug. 25-26, 1912, when nearly 8 in. of rain (about 25 per cent of the annual average fall) was precipitated in and around the city of Norwich in 24 hours and wide damage was caused to crops and animals nearly all over the country.

While it would be impracticable in ordinary cases to make provision for such abnormal conditions as occasionally present themselves, it would be unsafe not to provide drainage capacity for more than the daily average run-off of the wettest period. The degree of allowance to be made has been the subject of much discussion and no little difference of opinion among engineers of great eminence and experience. Drainage schemes have been designed to accommodate run-off volumes varying between ¼ to ⅓ in. of rainfall in 24 hours due to an annual average fall of 32 in. over very similar catchment areas.

It is quite established by experience that surcharged soils discharge their water more rapidly when under-drained and to that extent hasten flood conditions in the larger channels. The fact that well-drained land cannot be water-logged serves to show that larger main channels have become necessary since under-drainage became general.

The late Mr. Bailey Denton called water discharged by under-drains "new" water, arguing that, as before drainage, water was retained in and later evaporated from the soil, it was now discharged as water instead of being converted into vapor. Estimating the extent of land systematically under-drained in England and Wales up to 1877 at 3,500,000 acres, he deduced that the annual additional run-off due to under-drainage would amount to about 90,000,000,000 cu. ft. which would be approximately equivalent to a wet year's discharge of the River Thames.

For the Fen districts with an average rainfall of 24.9 in., and where under-drainage is perhaps less necessary than in more retentive soils, the late Mr. W. H. Wheeler recommended that the capacity of main drains should be equal to a run-off of ¼ in. of rainfall in 24 hours.

As has been previously indicated, absolute safety from occasional flooding due to abnormal rainfall can seldom be provided against, but a good general provision against super-average discharges may be found by multiplying the daily avrage of the wettest period by 5 and designing the capacities of the drainage channels upon the assumption of the resultant volume.

Adopting this figure for drainage capacity, we should have, for each acre in an average catchment area, 3.165 in. of water as a basis of the volume to be run off to sea. This volume is so nearly 1 per cent of the total annual rainfall—32 in.—that it may be safe to adopt as a general rule for an average catchment area in England and Wales, that the discharge capacity of main channels should be equal to a daily run-off or 1 per cent of the annual average rainfall of the district.

Factors That Must Be Considered in Design of Outfall Channel.—In regard to outfall channels, a number and variety of circumstances necessarily have to be taken into account. These may include, apart from tidal influences, the occurrence of sinuosities in the course of the channel the liability of the channel to silt up owing to deposits of detritus from the sea or alluvium brought down by the river, or both; irregularities of cross-section due to "bottle-necking" in the width or shoaling in the depth; sand-bars at the mouth or a tendency of littoral drift to pile up obstructions in or across the estuary and other possibilities, any of which might reduce the capacity of the channel to carry off its water and would dictate a necessity for some addition to the theoretical sectional area.

The general effect of sudden bends or those of short radius is to encourage accretion on the convex and erosion on the concave sides. The tendency of moving water—obedient to the general law of motion—to move in a straight line until influenced by some force outside its line of direction, causes the mass of water to impinge upon the concavities of any bends in the channel, so giving rise to erosion of the bed and banks. The consequence of this action is to deepen the channel in the vicinity of the concave side. Deepening may result in the removal of the necessary support for the banks whose toes and faces are further eroded by the scooping or fretting action of the water which, thrown out of its normal line of direction, grinds its way round the inside of the curve until it reaches some straighter course along which it may resume its interrupted mid-channel course. The local deepening of the channel causes also a local increase of velocity on that side of the stream, but this increase is counter-balanced by a local reduction of velocity on the opposite or convex side, where, owing to the occurrence of comparatively slack water, any solids held in suspension are almost sure to be deposited.

Apart from siltation due to bends, very large quantities of solids brought in by the incoming tide may be deposited along the bed of a channel during the short period of quiescence at high tide or during a slow ebb.

Sand-bars or shifting shoals are a more or less common form of trouble which arises particularly just beyond the reach of the scour of the fluvial and tidal channel. Where the deep stream begins to spread out and shallow into the mouth of an estuary; the scouring force of the water is reduced and dissipated by lateral deflections, and any tendency there may be towards sedimentation is thereby promoted. The effect upon navigation may be troublesome, for the old channels may have to be kept open by dredging. In these cases the interests of navigation and drainage are in some measure correlated. Where, however, there is little or no navigation, conditions may grow so serious as prejudicially to affect the discharge capacity of the outfall channel.

All such risks and tendencies must be carefully studied, and so far as possible, guarded against in the determination of the sectional area of an outfall channel. The main object to be achieved is to allow the water as uninterrupted and even a flow as possible. The best course is one long sweeping curve pointing in the direction of the littoral drift, or, if that cannot be obtained, one with curves of very long radius. The gradient of the bed need not be steeply inclined, but the bed should be as low as possible from the upper tidal limit to the greatest reachable depth below low water at sea, so as to encourage deep tidal action. If deep water cannot be otherwise reached, training banks should be pushed out towards deep water in order to confine and concentrate between them the scouring force of the fluvial currents.

The velocity of a stream varies as the square root of its depth. The deeper the stream the greater therefore will be its scouring effect, or, in other words, its capacity to maintain its own channel against fouling, for not only does a deep stream move with a higher velocity than a shallow stream, but to the increased velocity has to be added the higher grinding effect of mere weight of water on the bed. The difference in velocity of two streams, say, of 9 ft. and 16 ft. depth will be as 3 is to 4, but the difference in the weight of water moving over those depths will be at 56 is to 100.

As the whole object of land drainage is to get surplus water away to sea in the shortest possible period of time, the aim should be to merge the fluvial and tidal influence with as few and as slight interruptions as thought and skill may devise.

Arterial Channels Above Tidal Limits.—As in tidal channels, so also in non-tidal channels, allowances must be made for deterioration and the consequent reduction of discharge capacity. Accidental and seasonal causes usually operate with more damaging effect to up-country than to tidal channels, and for that reason a generous allowance should be added to an otherwise accurately ascertained area for any required discharge.

If the channel were quite straight; running between well-shaped banks of gault or clay or chalk, unfringed by trees or bushes; not used by cattle for drinking or sheltering, and otherwise very favorably conditioned, the only allowance needed might be that for summer weeds. If, however, the channel ran through "light" land, were sinuous and therefore liable to shoaling at the convexities and scouring at the concavities with a consequent tendency towards the undercutting and slipping of banks; if, as a further consequence of irregularity of course and section it were liable to rapid siltation and the concomitant propagation of weed and growths; if it were liable to receive large quantities of falling leaves during the autumn, or to become constricted by ingrowths of trees or bushes, or if the sides were liable to be trodden in by cattle; if, in short, the channel were of the average English character, a fairly liberal allowance would have to be made for deterioration.

In arranging for the improvement of a defective course or an inadequate cross-section, it may be of considerable importance to provide that the normal maximum water level in the improved channel shall be below the outfall ends of any pipe drains Large sums of money have been expended from time to time in the underdrainage of agricultural lands with the object of freeing them from a liability to waterlogging, while in too many instances the money and effort have been wasted owing to the subsequent super-elevation of the water level in the streams due to neglect of their channels.

It is to be remembered that when the outfall ends of pipe drains are submerged, the drains not only fail to act properly, but that river water enters them and passes up by what then become irrigation channels into the very lands which were sought to be drained.

Other circumstances permitting, an increase of the depth of the bed of the channel is the first and best course to adopt; but circumspection must be used, as too great an increase of depth may easily defeat the object in view. If, for example, the nature of the soil which composes the channel were of very loose texture, such as sand or sandy loam, it might be very risky to excavate or dredge the bed to any appreciable extent without at the same time cutting back the banks to such a slope as might be otherwise unnecessary.

The bed of a channel is the natural base upon which the sides rest. If that base be of such a nature that it will not bear having part removed without jeopardy to the support of the sides, very little deepening can be done. If, however, deepening and widening form part of one operation for improvement, depth should be kept as low as possible consistently with the safety of the banks.

It is in any case necessary, when arranging for the lowering of the normal water level in a river channel, to pay some regard to the fact that the banks will lose part of the support which the horizontal thrust of the water gave them.

It is better in most cases to arrange that deepening and widening shall be carried out as a single operation, and that the sides of the channel shall be sloped back from the improved bed level to as great an inclination or "batter" as the circumstances dictate.

The regradation of the bed of a natural channel to its natural inclination is seldom possible in practice. The inverts of bridges or culverts may be too high, or other factors may be present which would prevent the formation of an even gradient from end to end of the length to be improved. Where there are immovable physical ordinates such as bridge inverts, the gradation of the bed should be as far as possible arranged so as to be even and continuous over the section of channel between each such point and the point next above or below it.

The provision of open-ended flood water reservoirs or "washes" is sometimes desirable as an alternative or a supplement to other means of improvement, but these can only be arranged by building embankments alongside the course of the channel, or, in the case of a sinuous course, in moderately straight and parallel lines between which the sinuosities of the natural channel may wander. The provision of embanked washes may occasionally offer a valuable alternative to straightening a winding channel. Little land is lost, as the washes can be grazed by cattle and sheep during the greater part of the year.

Drainage of Depressed "Levels."—In discussing the discharge capacity necessary for an arterial system, 1 per cent of the average annual rainfall was mentioned as a sufficient maximum for the whole of the lands, comprising uplands, midlands, and lowlands; but it is obvious that, in any considerable catchment area, some will contribute more and others less in a given time than that due to their area measured in acres. Their greater or less permeability or their greater or smaller departure from the horizontal will necessarily affect the proportion which their average run-off bears to the total. Whilst retaining, therefore, our figure for the total run-off, we may need to make provision in marsh, or fen areas for the circumstance that in winter they evaporate scarcely any of their rainfall and that, owing to their depressed level, practically none of it can soak away.

A heavy rainfall does not necessarily produce flood conditions in a flat area. If the rain occurs after a spell of dry weather, a large proportion of it sinks into the ground, and some time may elapse during the period of exceptional wetness before the land becomes saturated. When, however, the rain is continuous over a long period, or occurs after the soil is fully changed, floods must result.

It is in order to prevent or relieve flood conditions that the various factors should be principally determined, but some maximum level of saturation for ordinary conditions of climate and seasons should also be fixed before the final provisions are made.

It may be convenient to arrange that the normal level of the water remaining in the cuts during dry weather represents a saturation level in the lands of not more than 18 in. This is the irreducible minimum if the soil is to be regarded as other than "wet" and anything up to 3 ft. 6 in. is better. If it is fairly certain that the land will be kept under grass, 24 in. might be a safe level; if, however, it is to be cultivated, 3 ft. 6 in. is not too low for the saturation level.

Owing to capillary attraction and frictional resistance of the soil, the saturation level will be slightly higher than the water level in the drains. If, therefore, it be decided to leave the summer saturation level at, say, 30 in. below the surface of the soil, the bottom levels and areas of the drainage cuts must be arranged so as to leave the normal water level in the cuts at about 33 in. below the surface. If the land, light or heavy, is likely to be underdrained, provision must be made for the rapid filling up of the cuts in exceptionally wet seasons.

A good proportion between depth and width of drain is of considerable importance, but it is not often possible to secure an approximation to a proportion of 1 to 2. In ascertaining the required cross-sectional area, we may get a drain which is either too wide or too narrow or too narrow to give a good proportion. If the drain has to discharge through an automatic sluice into a tideway, the higher the cill is above low water the flatter will be the gradient and the longer will be the period of discharge. We may have to choose between a shallow and wide drain with a high outfall and a longer discharge period, and a deeper and narrower drain with a better gradient and a shorter discharge period. A better sectional area and velocity will be secured in the latter case, and this might perhaps offset any disadvantage due to a shorter discharge. There may, too, be a smaller tendency for the sluice to get "landed up" with silt. Outfall sluices near, at, or below low water may usually be depended upon to remain free from silting owing to the flushing power of the land water coming down a steeply inclined drain. Preferably the outfall sluice of a main drain should discharge into a concave bend of the artery, where the water is likely to be deeper than at other parts.

Pumping Plants.—In very low-lying land, either near the coast or further inland where the arterial channels bringing their water down to the sea are embanked across the levels, it may be impossible to discharge the low-level water otherwise than by pumping it over the embankments by which the level is protected from external water. In other instances, discharge by gravitation can be obtained only when the outside water falls to or below that of the drains.

There are comparatively few cases in which the whole of the water must be pumped, but there are great areas, especially in the Fens, where dependence upon gravitation alone would be fatal.

In average seasons, gravitation and pumping systems usually discharge by simple run-off during eight or nine months in a year, the remainder of the duty being discharged by the pumps. The periods are sometimes very unequally divided into days or weeks of one or the other, but experience seems to show that fuel and oil for, say, five months will more than suffice for the year's consumption. The pumping periods are naturally longer in winter than in summer, but the capacity of the pumping plant should be such that it could cope with the whole of the year's volume if required. For this purpose it may be worth consideration whether the plant should not be duplicated or that there should be, if not a pair of engines and a pair of pumps, one engine driving either one or two pumps as may be necessary.

The advantages of duplicating pumping plants are (a) that economies in working are effected during periods of light duty when one set only may be needed, and (b) that in the event of a breakdown one set can be kept running while the other is undergoing repair.

The capacity of the pumping plant and the power of the engine or engines to work it depend upon the weight of water to be discharged in a given time and on the height of the "lift."

As the lift is usually variable with day to day conditions, the maximum lift should be provided for. The total lift is the difference between the lowest surface level of the water in the drain and the highest surface level of the water in the outside channel.

Field Ditches.—The modern tendency to use power plant instead of horses for ploughing, harrowing, drilling, etc., is likely to open up in the near future several new questions in connection with the drainage of cultivable lands. There is a growing tendency to grub up hedges, fill in ditches, and turn two, three or more fields into one, with the consequence that the total area loses some of the open channels by which it was formerly drained.

If, as is probable in the case of well-farmed lands, pipe drains of adequate dimensions have been provided to carry off the water which formerly flowed by the ditches before they were filled in, the general balance of advantage might lie with the new arrangement, as the trouble and expense of keeping the ditches properly "bottomed-out" and free from rubbish would be saved, while the drains would not only be likely to draw from a wider area than the ditches, but would be free from the action of frost.

It is quite a nice question whether all ditches of, say, less than 4 ft. width should not be piped and filled in. The first cost might be considerable, but the cost of upkeep and maintenance of the watercourse would practically disappear, while the effectiveness of the drainage would probably be much enhanced.

Where it exists, the field ditch should be so maintained as to conform to the general principles laid down for other portions of the arterial system.

Wherever possible upland and low-level water should be kept apart, but it is often found in practice that field ditches are essential links in a long chain of channels by which water from the uplands is carried down, often by very devious routes, into the main arteries. If they are not of sufficient depth to conduct that water past the lands of the lower levels, the latter are liable to suffer from flooding by upland water. In any case, that water might rise to a sufficient height in the ditches to seal the ends of any tile drains which should discharge into them or even to flow up those drains. Where, therefore, upland water is conducted by a ditch, that ditch should be more than ordinarily deep.

Field ditches which discharge into upland-water ditches need not necessarily be so deep as the latter, but they should be of sufficient depth to ensure that the normal level of their water should be well below the outfall ends of any tile drains which may discharge into them. The outfall ends of the ditches themselves should be sloped off, say, from 20 to 30 yards back from the upland-water ditch, so that their water has not to make a sudden vertical fall into the main ditch which might otherwise become liable to be blocked up by masses of earth washed in from the end of the higher-level ditch.

Every ditch which falls into another ditch or into any other channel should have its outfall end curved at easy radius into the other so that the two streams may not unnecessarily conflict to the detriment of the flow of each.

The shape of a ditch is of some importance, but it is sometimes impossible to give to the slope nearest the hedge the necessary amount of batter. It might be as well for several reasons not to attempt to cut back too much of the side of a ditch on the hedge slope, one reason being that an uncovering of rootlets might encourage an extension of the hedge growth into the channel of the ditch. On the other side, however, the slope should be as a rule not less than 1 horizontal to 1 vertical measured from the finished bed of the ditch after its width and slope have been improved to ascertained requirements.

Where ditches traverse or skirt pasture fields they should as a rule be fenced against cattle, and a drinking pool should be provided, as otherwise considerable damage to their banks and beds might be caused by cattle when watering or sheltering under the hedges during bad weather.

Under-Drainage.—The practice of under-drainage is already so prevalent that few words are needed to recommend it. The methods also are so widely and so well understood that it is perhaps unnecessary to do more than recapitulate them.

The depth at which the pipes should be laid will naturally depend upon the nature of the soil and upon the possibility of good outfalls for the mains.

If the ditches will not permit of a lower outfall than 2 or 3 ft. below the general level of the land, that must of course fix the maximum depth, but in ordinarily tenacious soils it is generally better to go deeper than 3 ft. Probably 3 ft. 6 in. is a good all-around depth in average soils, although Prof. K. Kinglak, of Wisconsin, advises a minimum depth of 4 ft.

Drains should always be laid so as to run with the fall of the land. This has not always been the practice, but the experience has proved the advantage of this course. The main or mains should, as a rule, take the lowest levels, but it may be sometimes more convenient to place them centrally to the fields to be drained despite that not being the lowest line of surface.

The inclination of the main towards the outfall need not be great; indeed some long mains which have had to be laid dead level have acted very well, but in these cases the diameters were not less than 6 in. The better the inclination the smaller need be the diameter, but in no case should a main have a less diameter than 4 in.

The outfall ends of the mains should be embedded in concrete and led over a concrete or stone cill into a catchpit built clear of the alignment of the outfall ditch. The catchpit should be of sufficient capacity to contain, say, three months' accumulation of sand or silt from the drain. It is prudent in most cases to protect the ends of the mains by means either of a wire cap or a little clough so as to prevent the entry of vermin.

The laterals, which should be led into the mains at a slight angle towards the outfall, should never be of less than 2½ in. in diameter, and had better be 3 in. if the mains are of 5 or 6 in. Their distance apart will depend upon depth and the nature of the soil, but supposing they are not less than 3 ft. deep the distances may be as under

In sandy soil	60 to 75 ft.
Sand with clay	30 to 50 ft.
Heavy loam	25 to 30 ft.
Stiff clay	15 to 20 ft.

The inclination of lateral drains towards the mains should be not less than 1 ft. in 10 chains.

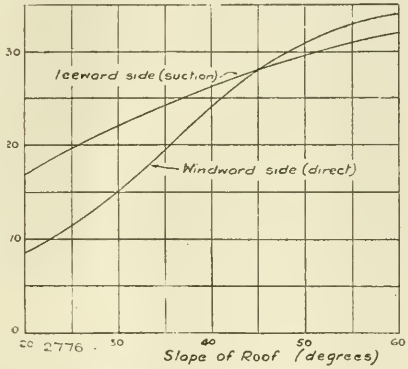
As a rule collars should be used. They do not prevent the admission of water to the drains, and are extremely useful in preventing short lengths dropping out of alignment due to local movements of earth.

Wind Pressure Diagram for Use in Design of Roofs

From The Engineering Review.

The accompanying diagrams will be found useful to structural engineers who wish to make allowance for suction or internal pressure in the design of roofs.

The pressures are derived from the coefficients obtained in Stanton's experiments carried out at the National Physical Laboratory some years ago. For some reason, which is very difficult to ascertain, these figures do not appear to have found their way into the structural drawing offices. The curves give the pressures per square foot to be taken in design corresponding to a wind of 100 miles per hour—a speed very seldom reached in this country, and never reached in many localities.



Wind Pressures on Roofs.

Curves give pressures per square foot to be taken in design, corresponding to a wind of 100 miles per hour.

In the design of roof trusses allowance should be made for windward (direct pressure alone), and for windward (direct) and leeward (suction) pressures acting together.

Annual Meeting of British Association of Consulting Engineers

From The Surveyor, London, June 4, 1920.

The annual meeting of the British Association of Consulting Engineers was held May 28.

In moving the adoption of the report of the committee for the past year, the chairman remarked that there had been a considerable amount of important work done. As stated in the report, a sub-committee had been engaged in drawing up a model general set of conditions for use in work carried out on a prime cost and profit basis, a method of carrying out work which had become more and more general, and he thought that it would be of very great use if the association could agree on a set of general conditions for that purpose. The sub-committee had not yet concluded its deliberations, but as soon as a set of conditions were drawn up and agreed on they would be circulated among the members of the association.

Another matter that had called for attention was the formation of the Federation of Civil Engineering Contractors, which had been formed by the leading firms in the country engaged in civil engineering work. They had combined and were asking for an overriding clause to be inserted in all engineering contracts, a clause which in its present form was not one which the association could accept. The federation had, however, asked the association to appoint three members to meet their representatives to consider the matter and, if possible, to come to some arrangement, which he had no doubt they would be able to do. As far back as 1914 the committee had had under consideration a model set of general conditions of contract for electrical work, which was drawn up by the Institution of Electrical Engineers, and to several causes of which the committee of the association took exception. The framers of the conditions appeared to consider that electrical work required a different set of conditions of contract to those used for other work, but the association held a contrary view. The matter had been in abeyance since the beginning of 1915, when the objections of the association had been sent in, but the whole question had now been reopened. The institution were revising the model general conditions and has invited the association to send a representative to sit on a committee formed of all the various interests connected with electrical work. As far as matters had gone at present, he was glad to say that the manufacturers had agreed to modify practically every clause to which the association raised objections, and he thought that eventually the electrical conditions of contract would come into line with the general conditions that were inserted in their civil engineering contracts.

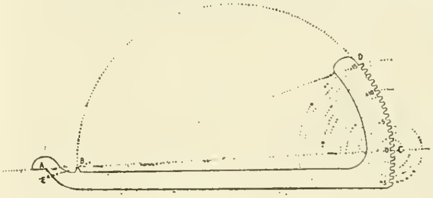
He was pleased to note the recent statement issued by the Council of the Institution of Civil Engineers as to the justification for increasing fees over prewar rates. The council suggested that the rise in the cost of work automatically increased the engineer's remuneration to the extent necessary to meet his increased expenses, but that in certain cases where, owing to unforeseen difficulties with labor or the supply of materials, the time of completion was delayed, he was justified in charging an extra fee, which in the case of works abroad might amount to a serious increase in pre-war rates. In respect to reports, inquiries, parliamentary work, and general advice on engineering matters, the council were of opinion that civil engineers were justified in making an advance of 50 per cent on pre-war rates. These views supported the action taken by the committee of the association.

A New Gauge for Measuring Water Levels

From Water and Water Engineering, London, April 20, 1920.

In using a measuring weir for hydraulic experiments, the writer had difficulty in finding the zero of the hook gauge. A mason's level and straight-edge were not accurate enough; a surveyor's level, after some years of use by an Indian surveyor, was not much better, even after adjustment; in the end, the pond was carefully filled to weir level and a gage reading taken, but there was still liability to error in judging the level.

A simple gage without moving parts was devised, that gives a fine reading of the difference of level between weir crest and standing water in the pool, when this difference is small. This is made of thin sheet metal, with a platform at A to lie on the crest; a point at B to be brought to water level and at C, a ladder forming a scale on which the water surface marks the required difference in level.



Gauge for Measuring Water Level.

In the figure AC is a straight line, and BC = 10 × AB; with BC as diameter describe a circle; about C as center describe circles of radius 10 times the readings wanted. At A form the platform and at B the point mentioned; form the ladder on lines connecting B to the intersections of successive small circles with the big circle, and number the scale; make the rest of the gage of convenient shape.

Imagine A resting on the weir crest B and the scale mark D at water level; let E be on the water surface vertically below A, so that the height AE is the quantity required. Now AEB and BDC are right-angles, and the angles ABE and CBD are equal; since BC has been made 10 times AB, by similar triangles CD is also 10 times AE, and the scale gives the quantity required.

Sewage Disposal Methods of London

From The Surveyor, London, Feb. 27, 1920.

The Main Drainage Committee of the London County Council was recently requested to consider and report on schemes "having the object of saving a large sum of money by the utilization of the sewage of the Metropolis."

As a preliminary to the consideration of the matter and to enable the council to judge of the magnitude of the problem of the disposal of the sewage of London and the outlying areas which drain into the metropolitan main drainage system, the committee, in the report which they have now presented, point out that the average daily quantities of sewage discharging at the outfalls amounts to nearly 290,000,000 gal. After the sedimentation of solid matter the effluent is run off into the Thames, and the sludge, amounting to over 2,000,000 tons annually, is discharged to sea by means of the sludge vessels. The sludge itself contains about 92 per cent of water, and the actual solid matter in the sewage is estimated at about 150,000 tons a year. It is, the committee add, in the separation of this large proportion of water from the solid matter that the difficulty, hitherto insuperable, of making commercially available the small amount of valuable matter in the sludge, arises.

During the war, when the need of the country was greatest, the question of the extraction of grease and other marketable properties from the London sewage was carefully examined. An examination at the northern outfall of the accumulation of matter in various places where fat might be expected to collect did not reveal the presence of any material which was likely to be suitable for extraction or treatment of any kind. At great cost and under the most favorable conditions it might be possible to obtain a mixed grease which could be used for the manufacture of very cheap lubricants. Undoubtedly the proper way to conserve fat is to trap it before it gets to the sewers.

The London sewage also contains nitrogen, in the form of ammonia, to the extent of .005 per cent, which escapes in the liquid portion or effluent. The dry matters in the sludge contain about 2 per cent of nitrogen, but the drying or pressing would be a costly matter, and the resulting material would be in a form unsuitable for distribution and decomposition in the soil, besides not being worth enough to justify much handling. While it may be urged that so much useful material is lost to the land, it may be pointed out that the large contribution of nitrogen from the land to the sea is at least in part counterbalanced by an increased yield of the harvest of the sea. The ultimate source of the nutriment of sea animals is, however, largely a matter of surmise. It is certain that many kinds of edible marine animals concentrate in narrow seas and in the neighborhood of estuaries.

"In addition to the experimental work which is carried on by the council's officers attention is carefully given to the efforts of other authorities. The conditions which govern this matter in inland towns and in towns within reach of the sea must differ. Having no other means of disposal of sludge, certain inland authorities, after dewatering the sludge, sell the residue, which has a certain small value, as manure. Such a process has been in use at Glasgow for some years, but the quantity so dealt with tends to decrease and the greater part of the sludge from that city is now discharged at sea. At Manchester a small quantity of dried sludge is sold for manure, but in no case has the system been found worthy of adoption on a large scale. The bulk of the Manchester sludge is discharged at sea.

At the present time the whole question is being investigated by the Ministry of Agriculture and Fisheries and the Ministry of Health, but the problem is eventually an economic one. Unless a method of utilization of sludge can be devised that is less costly than, and as efficacious as, conveying it in bulk to sea, there can be no justification for altering existing methods in London. The conveyance of the sludge to the Thames estuary is, relatively speaking, a cheap operation, and even if methods were evolved which would prove commercially practicable in inland towns they would possibly not be found to be commercially sound in the case of London.

Before the outbreak of war the committee had under consideration certain facts relating to important experimental work in the biological treatment of sewage, in which much of the early pioneer work was done by the council's officers. A new process was being developed in the prolonged aëration of sewage. This treatment alters the physical and biochemical features of the suspended matters in the sewage, and they assume the character of a purifying agency, which results in the production of an effluent of excellent quality and an inoffensive sludge, altogether different from ordinary sewage sludge. The possibility of the sludge or products obtained from it proving of commercial value is being examined in various quarters, but no assurance upon this aspect can be given at present. The process in question, with modifications in the mechanical means adopted, is being operated with success at certain provincial towns, notably at Manchester, Sheffield and Worcester. Experiments have been conducted in the council's laboratories and, after many failures and adjustments, a successful result has been obtained on a small scale, but sufficient to justify investigations on a practical scale. At this stage direct operations by the council's staff were suspended on account of the war, but the matter has been repeatedly under our consideration.

Since the adoption in 1887 of the present method of disposal of sewage at the northern and southern outfalls by the precipitation of the soil matters and their conveyance to the Thames estuary, the effluent being run off into the river at the outfalls, the quantity of sewage discharging at the outfalls has increased from 180,000,000 gal. a day to nearly 290,000,000. So far, the river has been able to assimilate inoffensively the effluents which have been discharged into it. The development for building purposes of vacant land within the area drained by the present system will, however, increase the quantities to be dealt with and may render necessary more intensive treatment. Any extension of that area may still further add to the problem. The committee is of opinion that the careful study of the question, including practical work, must now recommence in order that the council may be placed in a position to meet any eventualities which may arise in the future.

Excess Lime Method of Water Sterilization

From a paper by Capt. A. F. Girvan, read April 7, 1920, before the Institution of Sanitary Engineers.

The excess lime method of sterilization has been used successfully on a large scale at Aberdeen and at Accra, in West Africa.

This method consists in adding sufficient lime to the water under treatment to soften it and to leave a slight excess of free lime. The excess of lime has a strong bactericidal effect and there is no possibility of producing a taste. In the case of a soft water the method is economical, but a hard water requires so much lime to soften it that the cost is probably too great to be practicable.

At Aberdeen, where the water from the River Dee is very soft, the water was given a dose of 1 part of CaO for 100,000 parts of water, followed by seven days' storage and then filtration at about double the usual rate. The cost of the lime was about 24 ct. per 1,000,000 gal., and the saving in capital expenditure compared with alternative schemes was about $500 000.

At Accra it was necessary to have two large reservoirs for purposes of quantity. The source was polluted and at the prevailing temperature of 80° F. the water developed heavy algal growths and a very bad taste. Simpson and Houston advised treatment at the intakes with lime, leaving an excess of 6 parts CaO per 100,000. The reservoirs were used alternately, as it took about three weeks for the excess lime to be neutralized by the carbon dioxide in the atmosphere. The result was entirely successful, the water after the treatment being pure bacteriologically and free from taste, while the algal growth was stopped. This is the first case in which lime has been used for the double purpose of giving a sterile water and of arresting algal or plankton growth. In cases where it is not possible to store the treated water long enough for the excess lime to be neutralized by the atmosphere, it is desirable to neutralize the excess after a suitable time of contact by adding alum or mixing the water with a suitable proportion of unlimed but stored or chlorinated water from the same source

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